Biochemistry of Soil Organic Matter in Relation to Crop Production

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Content

Lecture 3.

The Role of Nitrogen in Formation of Humic Substances

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1. Participation of nitrogenous compounds in the formation of humic substances.

In cultures of microorganisms the formation of dark coloured nitrogenous humic like substances has been observed several years ago (BREMNER, FLAIG and KÜSTER 1955, KÜSTER 1952,1956, LAATSCH, HOOPS and BIENEK 1952, von PLOTHO 1950, 1951, SCHEFFER, von PLOTHO and WELTE and others).

The content of hydrolysable α-amino-nitrogen of the lignin fractions decreases during the humification of plant material, but the percentage to total nitrogen increases (see lecture 1). This can be explained in two ways. Either nitrogen as amino acids or peptides continues to condense with the lignin during humification, or the peptide chains are increasingly decomposed by the microorganisms. There is the possibility that both of these latter nitrogen reactions occur simultaneously.

Lignin degradation products can always be isolated during the course of humification. Furthermore it could be shown, that the formation of phenols or quinones is possible during oxidative degradation or by enzymatic dehydrogenation of lignin. In addition, it is known, that dark coloured polymers are formed during the oxidation of 1,2-di- or 1,2,3-triphenols together with amino acids in the presence of phenoloxidases, (STEINMETZ 1956, SWABY 1956, 1958, FLAIG 1956).

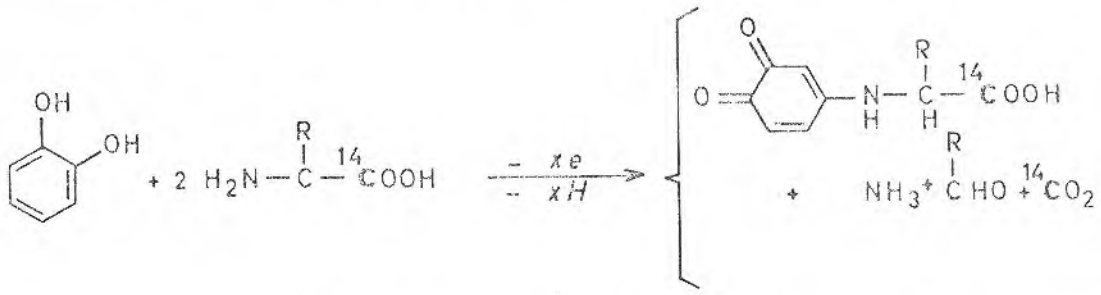

Fig. 1: Addition of amino acids on 1,2-diphenols or oxidative deamination during oxidation.

Investigations of the reactions occuring between amino acids and lignin degradation products in the presence of phenoloxidases showed, that besides the usual oxygen consumption during the addition of amino acids on quinones, by additional oxygen uptake the amino acids are deaminated and decarboxylated. These oxidative reactions are influenced by chemical structure, concentration and by pH. The investigations were made with labelled amino acids to elucidate the mechanism of the reaction. The labelled carbondioxide can be determined easily.

1.1 Conditions of the formation of N-free polymers.

Phenolic lignin degradation products are reactive compounds. Partially methylated o-diphenols and the o-diphenols themselves show some differences in the case of oxidative polymerisation.

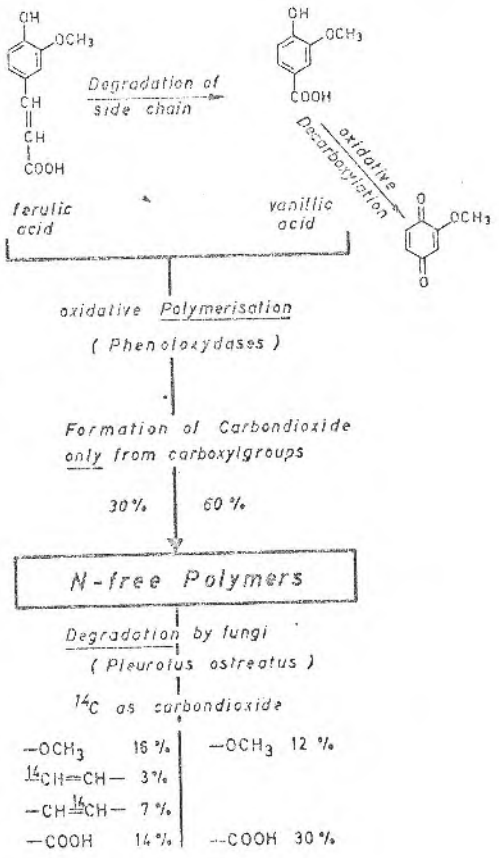

Fig. 2: Oxidative polymerisation of methoxyl substituted phenol carboxylic acids.

The methoxyl substituted lignin degradation products such as ferulic and vanillic acid polymerise in the presence of phenoloxydase from microorganisms. The dehydrogenative polymerisation occurs only when the monomers are substituted with a phenolic hydroxyl group in p-position of the side chain. In case of carboxyl-labelled compounds different quantities of active carbondioxide are split off from the two acids. No labelled carbondioxide is formed when the carbon atoms of the methoxyl groups of the two acids or the carbon atoms 2 and 3 of ferulic acid are labelled.

By oxidative polymerisation nitrogen free polymers are formed. No nucleophilic addition of amino acids occurs in the case of hydroxy-methoxy-compounds.

The polymers are degraded by white rot fungi, such as Pleurotus ostreatus. The carbon atoms of the carboxylic and methoxyl groups are more split off by the activity of the microorganisms than the carbon atoms 2 and 3 in the side chain of ferulic acid (HAIDER, LIM and FLAIG 1962, 1964).

Vanillic acid is transformed to methoxy-benzoquinone-1,4 by oxidative decarboxylation (SUNDMAN and HARO 1966) or to its dimer (FLAIG and HAIDER 1961a), The mentioned reactions are also interesting in connection with the uptake of lignin degradation products by the roots of plants, their translocation and transformation in plants and their physiological effect (summarized in: FLAIG, 1968) (lecture 7).

1.2 Conditions of the formation of nitrogenous polymers.

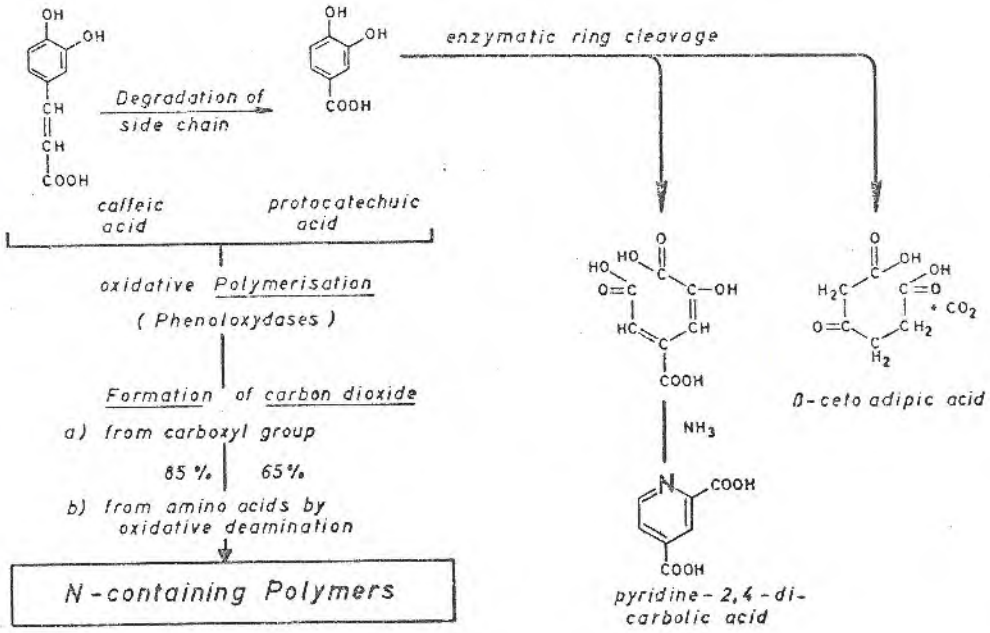

Fig. 3: Oxidative polymerisation of o-diphenolcarboxylic acids and their reaction with nitrogenous compounds.

Diphenylcarboxylic acids such as protocatechuic or caffeic acid polymerise also in the presence of phenoloxidases. But the released quantity of labelled carbondioxide is higher than in case of hydroxy-methoxy-derivatives. The formed polymers contain nitrogen, whilst the polymers in case of methoxyl substituted compounds were nitrogen free. A nucleophilic addition of amino acids occurs. In the presence of nitrogenous compounds from proteins the total released carbondioxide is partly derived from the carboxyl groups (case a) or from the amino acids and peptides (case b). The nitrogenous polymers are degraded much more slowly by microorganisms, this may be one of the reasons that such type of substances are accumulated in the soils.

As further reaction the cleavage of the aromatic ring of protocatechuic acid occurs and β-cetoadipic acid is formed during enzymatic oxidation (STANIER and INGRAHAM 1954, Mc DONALDS, STANIER and INGRAHAM 1954,

GROSS, GRAFFORD and TATUM 1956, OTTEY and TATUM 1956, FLAIG and HAIDER 1961 a). This aliphatic acid is easily available for the microorganisms. The formation of protocatechuic acid and the cleavage of its ring is an important reaction for the transformation of phenolic compounds from plants and microorganism during humification because some reactions lead by demethylation and hydroxylation to this o-diphenolic acid. By this way the aromatic compounds disappear from the mixture of compounds, which participate in formation of humic substances.

TRIPET, DAGLEY and STOPHER (1960) found an enzymatic cleavage of protocatechuic acid with cell-free extracts from Pseudomonas sp., whereby the semialdehyd of muconic acid is formed. This reacts with ammonia on a not enzymatic way to pyridine-2,4-dicarboxylic acid. This reaction may be considered as one example for the fixation of nitrogen in heterocyclic compounds.

1.3 Different reactivity of phenols participating in nitrogen fixation.

Among the identified phenols which are formed either by oxidative or reductive cleavage of humic acids, or isolated from soils or synthesized by microorganisms, there exist two types of phenolic compounds, which are of interest in studies of the structure and therefore also of the chemical and physical properties of humic acids.

After demethylation of lignin degradation products with side chains of 1 or 3 carbon atoms different phenols are formed which possess two or several hydroxyl groups in o-position. Dimerisation and polymerisation occur during oxidation. Many microbial synthesized phenols

have two or three hydroxyl groups in m-position. By hydroxylation also phenols are formed with OH-groups in o-position.

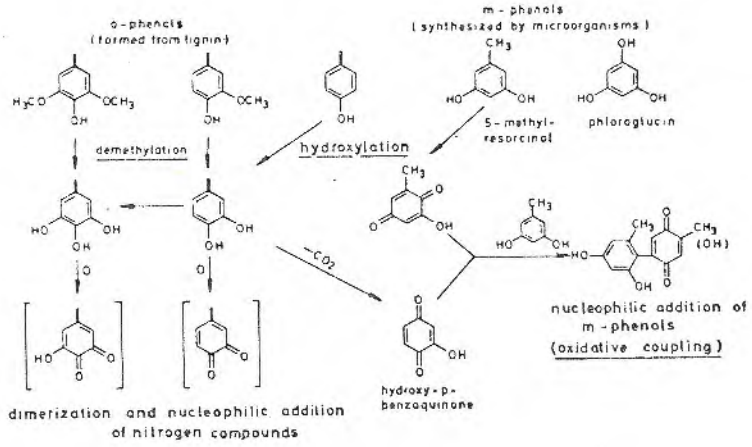

Fig. 4: Transformations of polyphenols under oxidising conditions.

The compounds with OH-groups in o- or m-position differ widely in their reactivity. Catechol, pyrogallol, hydroxyhydroquinone derivatives add nucleophilicly derivatives of resorcinol and phloroglucinol (MUSSO et al. 1965) as well as proteins or their products of hydrolysis during oxidation to quinonoid intermediates. Phenols with OH-groups in m-position do not. Phenolcarboxylic acids are transformed by decarboxylation to hydroquinone derivatives and by further oxidation to quinones.

The differences in reactivity are important with respect to the function of nitrogen in the molecule of humic acids. The oxidative coupling leads to ramification and increases aromaticity.

2. About the linkage of amino acids, peptides and proteins in humic acids.

2.1 Nucleophilic addition of nitrogen compounds by phenols during oxidation.

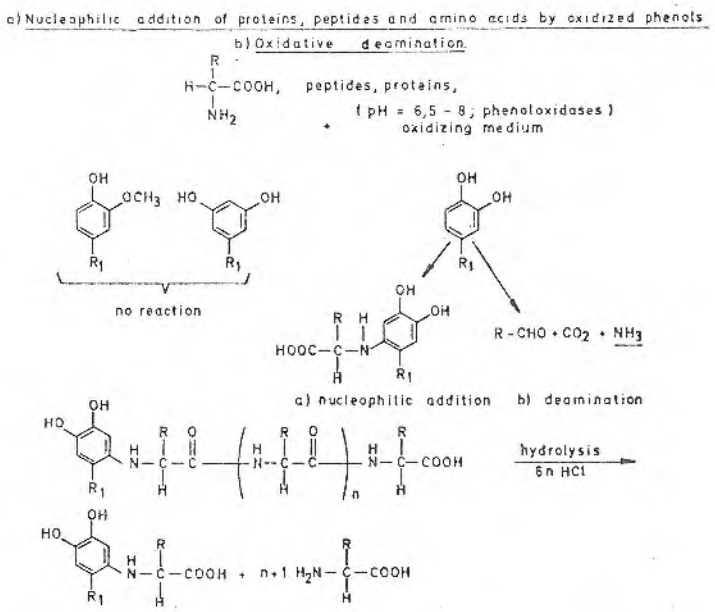

Fig. 5: a) Nucleophilic addition of proteins, peptides and amino acids by phenols during oxidation.

b) Oxidative deamination.

Extensive studies have been made with labelled amino acids about the possible linkage of proteins and of their products of hydrolysis to phenols during oxidation (HAIDER, FREDERICK and FLAIG 1965. Some lignin degradation products isolated from decomposing lignin from soils or some phenols of microbial origin can add nitrogenous compounds derived from proteins at variable rate and in different amounts during oxidation in the presence of phenoloxidases. Summarizing, we could establish, that guajacol and resorcinol derivatives however do not add amino acids in a pH-range of 6.5 to 8.0.

The rate of nucleophilic addition (a) is the highest in the case of catechol and hydroxyquinone derivates. Addition by pyrogallol derivatives occurs also to a smaller extent, dependent on the chemical constitution of the derivatives. By means of labelled compounds, it could be proved that the amino acids are added intact. An addition also occurs with peptides and proteins.

Oxidative deamination (b) is discussed later.

Furthermore, during oxidation in the presence of phenol oxidase and nitrogen compounds, catechol derivatives polymerise to nitrogenous polymers which have properties comparable to those of humic acids. In contrast, as mentioned before, the polymers of guajacol derivatives do not contain nitrogen (FLAIG and HAIDER 1961) (comp. 1.1 with 1.2).

After nucleophilic addition the amino acids cannot be hydrolized from the corresponding addition products by 6 N hydrochloric acid. In case of addition products formed with proteins and peptides, only the amino acids could be hydrolized with the exception of the N-terminal amino acids in which the amino group has reacted with the oxidised phenol (HAIDER, FREDERICK and FLAIG 1965, HAIDER and MARTIN 1970). Therefore not all non-hydrolizable nitrogen is bound in heterocyclic form as it is often supposed.

2.2 Oxidative deamination of amino acids

By oxidative deamination the amino acids are transformed in ammonia, carbondioxide and in a carbonyl compound.

If both reactions, addition and deamination, occur together more than 1 Mol oxygen is uptaken (HAIDER, FREDERICK and FLAIG 1965). One mole-

cule quinone gives one addition product, but deaminates several Mols of amino acids.

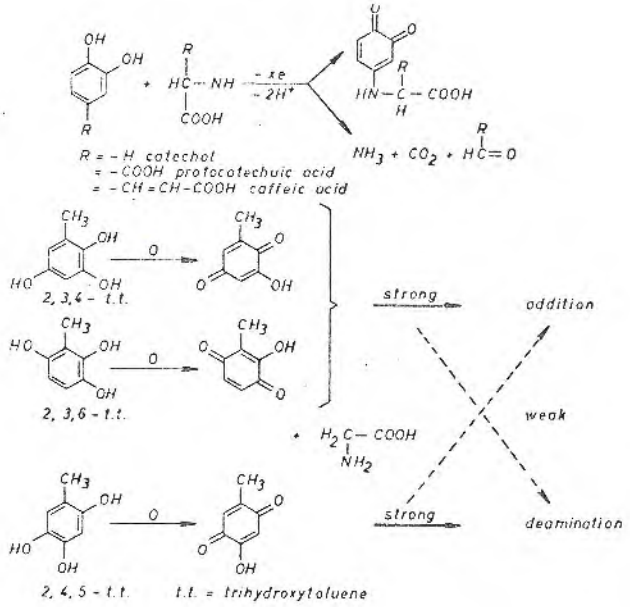

Fig. 6: Addition and oxidative deamination of amino acids by o-diphenols during oxidation in the presence of phenol oxidases.

The ratio of the two reactions such as the addition of an amino acid and its deamination depends upon the constitution of the added phenol.

2,3,5- and 2,3,6-Trihydroxytoluene or their oxidation products effect a strong addition but a weak deamination, whilst in the presence of 2,4,5-trihydroxytoluene the deamination occurs more strongly than the addition of an amino acid (HAIDER and MARTIN 1967). Two of these compounds 2,4,5- and 2,3,5-trihydroxytoluene are formed in the culture media of Epicoccum nigrum.

2.3 Properties of substances precipitable with acids (humic acids).

Precipitates can be isolated by addition of mineral acids to the reaction solution of phenols and amino acids. The precipitates are

the main part of the addition products.

Tab. 1: Distribution of the nitrogen in the reaction of 2500 µ mole glycine with 500 µ mole catechol (2500 µ atom N; 3 mg mushroom phenoloxydase)

	α-NH_2-N	NH_3-N	N-diff.*	N-prec.
nitrogen in µ atom in solution and in precipitate	1574	452	170	304

* Kjehldahl-N minus (NH_2-N + NH_3-N)

Precipitate	weight in mg	weight % of total appl.subst.	% N	N in prec. in % of total N	% NH_3-N of total N
	75,1	31	5,6	12	18

(According to HAIDER, FREDERICK and FLAIG 1965)

In one example the distribution of the nitrogen in the precipitate and in the solution is depicted. Under the mentioned conditions about one molecule of glycine is condensed with one molecule oxidised catechol, because the sum of the nitrogen in the precipitate and N-diff.-(that is the nitrogen in the solution, which is not α-NH_2-N and not NH_3-N) is nearly 500 µ atom like the amount of the applied catechol. The nitrogen N-diff. belongs to soluble addition products, which cannot be precipitated by mineral acids. The number for NH_3-N in the solution demonstrates, that a further molecule glycine is deaminated. The value of α-NH_2-N in the solution belongs to the not yet transformed glycine. The sum of all N-fractions is about 2500 µ Moles = the added amount of nitrogen.

The nitrogen content of the precipitate is 5,6 %; 12 % of the nitrogen applied in form of glycine are fixed in the precipitate and 18 % are released as ammonia. The numbers are representative for the most investigated acids.

Some properties of the precipitates are comparable with those of humic acids. The fixed amino acids of the reaction products with the phenols cannot be hydrolized with 6 n HCl. After electrophoresis or paper chromatography of hydrolisates no spots are observed, which belong to the applied amino acid. This result means that not all unhydrolysable nitrogen of the humic acids is heterocyclic bound. Some other linkages of nitrogen must have occurred perhaps in form of aromatic amines.

2.4 Distribution of the carbon skeleton and nitrogen as constituents of the amino acids in the reaction products and in the solution.

Some further experiments have been made, to elucidate, how the amino acids are transformed, and where the parts of the transformed amino acids remain during both reactions, during the addition and the deamination. For this purpose different ^{14}C-labelled amino acids have been used (HAIDER, FREDERICK and FLAIG 1965).

Tab. 2: Oxidative deamination of differently labelled amino acids during the oxidation of catechol in the presence of mushroom phenoloxidase (pH = 7). Distribution of the carbon[14] and the nitrogen in different fractions.

Amino acid	% added activity in		% added nitrogen in	
	CO_2	precipitate	NH_3 in solution	precipitate
$HC(NH_2)-{}^{14}\underline{C}OOH$	31	14	20	18
$H^{14}\underline{C}(NH_2)-COOH$	1	15	21	18
$HOOC-(CH_2)_2-CH(NH_2)-{}^{14}\underline{C}OOH$	21	6	16	10
$HOOC-({}^{14}\underline{C}H_2)_2-CH(NH_2)-COOH$	0,2	8	16	10

Catechol has been oxidised in the presence of amino acids labelled at different C-atoms and in the presence of phenoloxidase. (HAIDER, FREDERICK and FLAIG, 1965). When the oxidation was finished the reaction solution has been acidified till pH = 1. The released carbondioxide was absorbed in sodium hydroxide solution and the precipitation was isolated. The summarized results are the following:

1. The larger amount of released labelled carbondioxide in the case of carboxyl labelled amino acids in comparison to those, which are labelled in another carbon atom, is a measure for the deamination, because the activity in the precipitates formed in the presence of the two different labelled amino acids are in every case the same. Furthermore the activity in the precipitates formed with differently labelled amino acids demonstrates, that the amino acids are added as a whole in the oxidation product without a loss of carbondioxide.

2. The quantity of the released carbondioxide in the carboxyl labelled amino acids was larger than the amount of the ammonia nitrogen in the solution. Furthermore the nitrogen content in the precipitation was larger than their content of labelled carbon. These data indicate, that a part of the nitrogen in the precipitate is not bound in form of an amino acid. Further condensation must have taken place, by which nitrogen is bound in another way.

Experiments with labelled di- or tripeptides demonstrated, that not only nucleophilic addition of a peptide by a quinone but also deamination occurred. When the addition products have been hydrolized, all the amino acids were identified except the N-terminal, which is bound at the ring.

2.5 Mechanism of nucleophilic addition and oxidative deamination of amino acids by phenols.

We were interested in mechanism of the influence of molecular structure of the different phenols on addition or deamination of amino acids. The reaction between different substituted trihydroxytoluenes and glycine in oxidative medium was investigated by polarographic methods. (RIEMER 1970, FLAIG and RIEMER 1971).

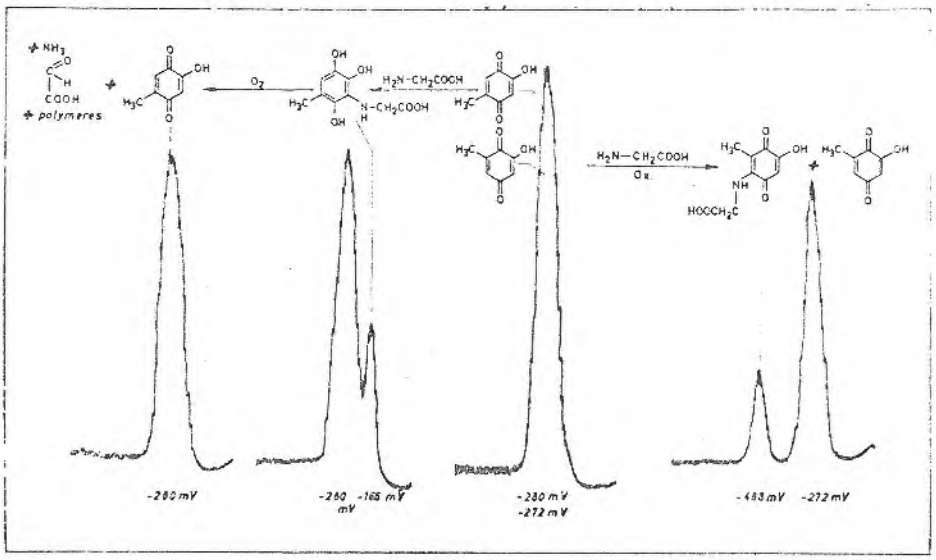

Fig. 7: Reaction of the oxidation products of different substituted trihydroxytoluenes with glycine; polarographic measurements.

The oxidation products of 2,3,5-trihydroxytoluene (right) adds amino acids in p-position to the phenolic hydroxyl group.

The addition product is very stable. Its half-wave potential is 216 mV more than this of the initial compound. Deamination does not occur in this case.

The stability of this addition product is caused by the increase of the p-quinoid part in the resonance hybride by interaction of the

electron donating substituents across the ring system.

In contrary to this, a slow reaction occurs with glycine in the case of 2,4,5-trihydroxytoluene (left) after oxidation to the corresponding quinone. The addition product has a more positive half-wave potential than the initial product. In the addition product with the higher half-wave potential the o-quinoid part of the resonance hybride is increased and decomposes by further addition of oxygen, whereby 2-hydroxy-5-methyl-benzoquinone-1,4 is formed again as well as ammonia, glyoxylic acid and polymers.

According to the polarographic investigations the reaction mechanism of addition of glycine to 2-hydroxy-5-methyl-benzoquinone-1,4 and the following oxidative deamination is depicted in the following scheme:

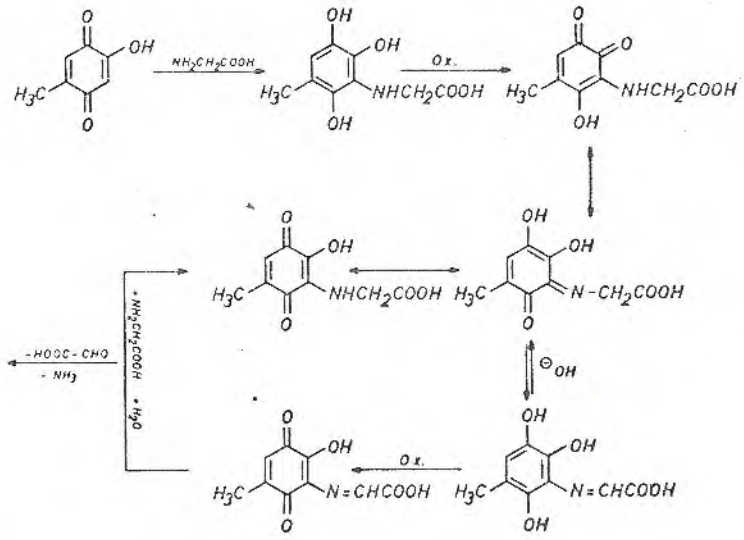

Fig. 8: Mechanism of oxidative deamination of glycine by 2-hydroxy-5-methyl-benzoquinone-1,4.

The first step is the addition of the amino acid on the quinone and oxidation to the corresponding o-quinone with the more positive half-wave potential. A tautomerisation to a pH-dependent equilibrium occurs.

Further oxidation leads to oxidative deamination by nucleophilic displacement with a further molecule of an amino acid. The former glyoxylic acid has been identified by polarographic measurements.

The catalytic effect of quinones with different molecular structure on nucleophilic addition and on oxidative deamination seems to be not only interesting for the formation of humic substances, but also in the connection with the physiological effect of phenols or quinones on plant metabolism, their uptake, translocation and transformation in the plant or their fixation as insoluble products in the roots.

3. Autoxidation of phenol derivatives in the presence of ammonia at pH-values about 8.

3.1 1,2- or 1,4-Diphenols.

Till now only the addition reactions in oxidising medium have been reported, which were catalysed by phenoloxidases and which occur in a range of pH-value between 6 and 8. At higher pH-values the phenols with at least two hydroxyl groups in o- or p-position react with ammonia to dark coloured nitrogenous polymers.

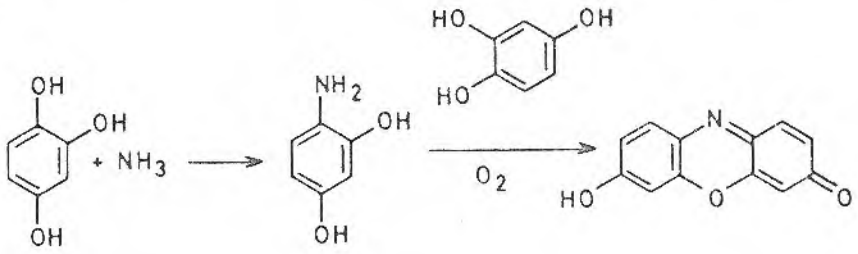

Fig. 9: Formation of phenoxazone derivatives.

In the absence of air and in the presence of ammonia a hydroxyl group can be replaced in hydroxyhydroquinone by an amino group (LANTZ and

MICHEL 1961). The aminoresorcinol thus formed reacts in the presence of oxygen with a further hydroxyhydroquinone to produce 7-hydroxyphenoxazone.

3.2 1,3-Diphenols

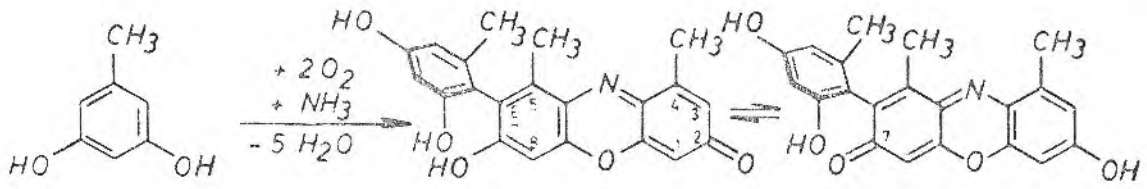

Fig. 10: Reaction of resorcinol derivatives (e.g. orcinol) during oxidation with ammonia. (Formation of phenoxazones; orcein dyestuffs) (MUSSO 1961).

Before it has been mentioned, that 3,5-dihydroxytoluene (orcinol) was found in the culture media of Epicoccum nigrum in the humic acids after reductive cleavage. Also such types of substances react with ammonia in an oxidising medium but only at higher pH-values than 8. MUSSO et al. (1961, 1963, 1965) investigated these reactions to elucidate the constitution of the orcein dyestuffs. For instance α-hydroxy-orcein is a tautomeric mixture of the derivatives from phenoxazone-2 and phenoxazone-7, which are also formed through quinonoid intermediate by the addition of ammonia at orcinol.

4. Random polymerisation of tyrosine to melanin as a model for the participation of heterocyclic nitrogen in formation of the spheric shaped humic acids.

A further possibility of the formation of dark coloured humic substances is the participation of aromatic amino acids from the protein of the

microorganisms. For example the oxidation of tyrosine could lead through the dopaquinone VII (RAPER 1927) to dark coloured polymers (CROMARTIE and HARLEY-MASON 1953).

The proposed random polymerisation of tyrosine to melanin (BLOIS 1965, MASON 1948, NICOLAUS 1962, RAPER 1928) can be used for the explanation of the formation of humic acids. Both are dark coloured, higher molecular substances with a spherical shape. The polymerisation occurs in each case through quinonoid intermediates, such as semiquinone free radicals.

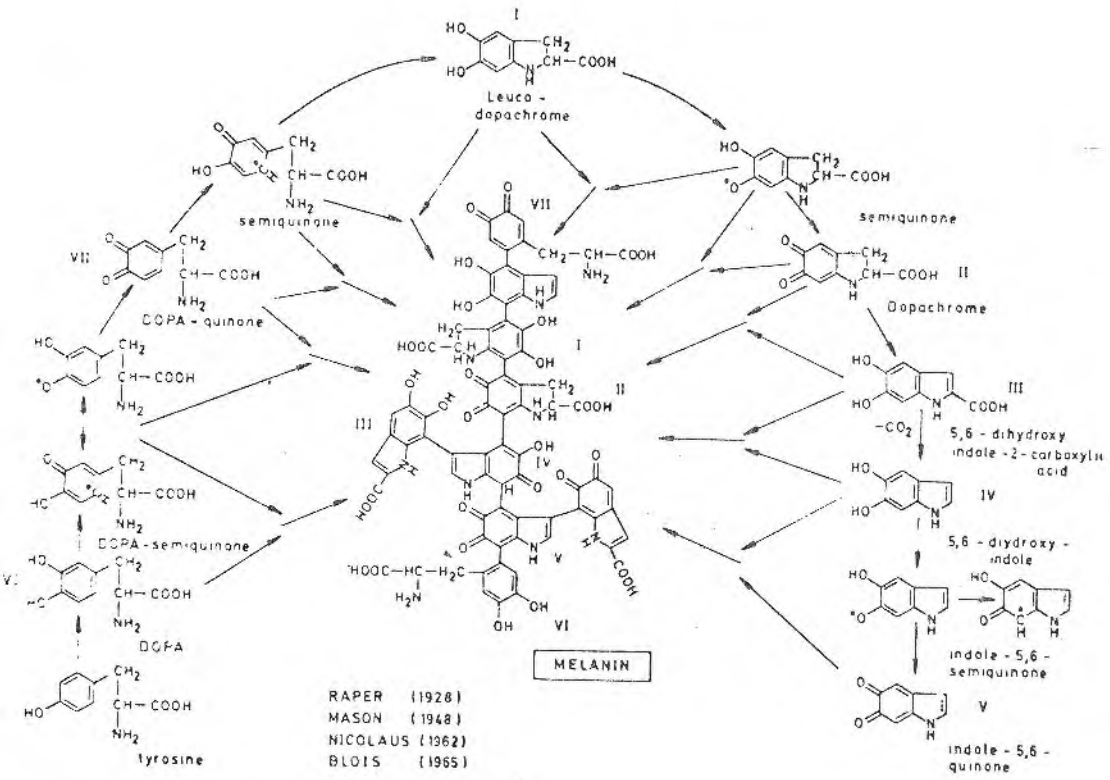

Fig. 11: Hypothetical scheme of melanin synthesis assuming the participation of semiquinone free radicals.

The random polymerisation to melanin starts from tyrosine and all intermediates participate in the formation of the polymer. Melanin is not only formed by the polymerisation of the end product of oxidation of tyrosine, indole-5,6-quinone.

Similar but much more complicated processes occur during the formation of humic substances, since not one but several phenolic components and various nitrogenous compounds take part in the formation of the polymers.

The formation of dark coloured substances in structurally intact dead plant tissues at the beginning of humification could be explained in a similar way (KONONOVA 1961).

This contribution to the participation of nitrogenous compounds in the formation of humic substances concerned much fundamental research work to this problem.

One of the functions of humus is its ability to contribute to soil productivity as a slow acting nitrogen source. Many field experiments and experiments with 15-N have been made to find out the dynamics of nitrogen transformations and nitrogen economy in soil.But all the observations, which have been made, cannot be explained without knowledge about their causal connections. We are here only at the beginning of research work. But the fact, that phenolic constituents of humus catalyse the liberation of ammonia from organic compounds such as amino acids, a product of dead soil organisms, seems to be a step for further elucidation of nitrogen economy in soil. Some of the mentioned reactions gave valuable suggestions for synthetic, slow releasing nitrogen fertilizers.

References:

ADLER, E.: Über den Stand der Ligninforschung. Z. Papier, 15,604-609 (1961).

AUDUS, L.J.: The transport of growth regulators in plants. Transporto delle molecole organische nelle piante. Atti del VI Simposio Internazionale di Agrochimica Varenna 5-10 Settembre 1966, 273-295.

BADZHOV, K. and E. IKONOMOVA: ^{15}N for studying nitrogen transformations in soil, nitrogen nutrition of plants and in assessing available nitrogen in soil. - Proc. Symp. Vienna 1969. - IAEA, Vienna, 21-32 (1971).

BAILEY, N.T., G.G. BRIGGS, G.J. LAWSON, J.M. SCRUTON and S.G. WARD: Observation on the structure of humic acid. 6. Intern. Kohlenwiss. Tagung, Münster, W., 1.-3.6.1965. Beitrag Nr.3, 1. (1965).

BARTLETT, J.B.: The effect of decomposition of the lignin of plant materials. Iowa State Coll. J. Sci. 14, 11-13 (1939).

BARTLETT, J.B., F.P. SMITH and P.E. BROWN: Lignin decomposition in soils. Proc. Iowa Acad. Sci. 44, 97-101 (1937).

BARTLETT, J.B.,and A.G. NORMAN: Changes in the lignin of some plant material as a result of decomposition. Soil Sci. Soc. Amer., Proc. 3, 210-216 (1938).

BEILER-KELBRITSCH, H. and B. RADEMACHER: Isolierung von Indolderivaten aus Laubkompost und deren Einfluß auf Stellaria media. Beitr. Biol. Pflanzen 40, 237-264 (1964).

BERTHELOT, M. and G. ANDRÊ: Ann. Chim. Phys. 25, Ser. 6, 362 (1892).

BIELAWSKI, J., T.E. THOMPSON and A.L. LEHNINGER: The effect of 2,4-dinitrophenol on the electrical resistance of phospholipid bilayer membranes. Biochem. and Biophys. Res. Comm. 24, 948-954(1966).

BEUTELSPACHER, H.: Physikalisch-chemische Beiträge zur Humusforschung. Z. Pflanzenernähr., Düng., Bodenkunde 57,57-65 (1952).

BEUTELSPACHER, H.: Natürliche Fadenkolloide und Krümelbildung. Landbauforsch. 5, 90-92 (1955).

BJÖRKMAN, A.: Isolation of lignin from finely divided wood with neutral solvents. Nature 174, 1057 (1954).

BJÖRKMAN, A.: Studies on finely divided wood. I. Extraction of lignin with neutral solvents. Svensk papperstidning 59, 477-485(1956).

BJÖRKMAN, A.: Lignin and Lignin-Carbohydrate Complexes. Extraction from wood meal with neutral solvents. Ind. Eng. Chem. 49, 9 1395-1398 (1957).

BLOIS, M.S.: Random polymers as a matrix for chemical evolution. In: The origins of prebiological systems, edit. by Sidney W. Fox, Academic Press New York-London 1965, 19-38.

BONDY, A. and H. MEYER: Lignin in young plants. Biochem. J. 43, 248 (1948).

BLUMER, M.: Benzyprenes in soil. Science 134, 474-475 (1961).

BÖRNER, H.: Untersuchungen über phenolische Verbindungen aus Getreidestroh und Getreiderückständen. Naturwissenschaften 42, 583 (1955).

BÖRNER, H.: Der papierchromatographische Nachweis von Ferulasäure in wässrigen Extrakten von Getreidestroh und Getreiderückständen. Naturwissenschaften 43, 129 (1956).

BÖRNER, H.: Die Abgabe organischer Verbindungen aus den Karyopsen, Wurzeln und Ernterückständen von Roggen (Secale cereale L.), Weizen (Triticum aestivum L.) und Gerste (Hordeum vulgare L.) und ihre Bedeutung bei der gegenseitigen Beeinflussung der höheren Pflanzen. Beitr. Biol. Pfl. 33-38 (1957).

BRAUNS, F.E.: Native Lignin. I. Its isolation and methylation. J. Amer. Chem. Soc. 61, 2120-2127 (1939).

BRAUNS, F.E. and D. A. BRAUNS: The chemistry of lignin; supplement volume: Covering the literature for the years 1949-1958. New York and London, Academic Press 516-518,(1960).

BREMNER, J.M.: "Organic forms of nitrogen". Ch. 85 Methods of Soil Analysis. (Agron. Monographs 9) ASA Madison 1965.

BREMNER, J.M.: The nitrogenous constituents of soil organic matter and their role in soil fertility. Pontificae Academiae Scientiarum Scripta Varia 32, 143-193 (1968).

BREMNER, J.M. and F. FÜHR: Tracer studies of the reaction of soil organic matter with nitrite. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA technical Meeting. - Pergamon Press Ltd. Oxford 1966, 337-348.

BREMNER, J.M., W. FLAIG and E. KÜSTER: Zur Kenntnis der Huminsäuren. IX. Mitteilung. Der Gehalt an Aminosäuren in Streptomyceten-Huminsäuren. Z. Pflanzenernähr., Düng., Bodenkunde 71, 58-63 (1955).

BREMNER, J.M. and T. HARADA: Release of ammonium and organic matter from soil by hydrofluoric acid and effect of hydrofluoric acid treatment on extraction of soil organic matter by neutral and alkaline reagents. J. Agric. Sci. 52, 2 (1959).

BREYHAN, Th.: Eine Mikromethode zur Stickstoffbestimmung. Z. analyt. Chem. 152, 412-417 (1956).

BROADBENT, F.E.: Nitrogen release and carbon loss from soil organic matter during decomposition of added plant residues. Soil Sci. Amer. Proc. 12, 241 (1948).

BROADBENT, F.E.: Modification in chemical properties of straw during decomposition. Soil Sci. Soc. Amer., Proc. 18, 165 - 169 (1954).

BROADBENT, F.E. and A.G. NORMAN: Some factors affecting the availability of organic nitrogen in soil - a preliminary report. Soil Sci. Soc. Amer. Proc. 11, 264 (1947).

BROCKMANN, H. and E. MEYER: Äquivalent- und Molekulargewichtsbestimmungen durch potentiometrische Mikrotitration in nichtwässrigen Lösungsmitteln. Chem. Ber. 86, 1514-1523 (1953).

BRUCKERT, S.F., F. JACQUIN and M. METCHE: Contribution à l'étude des acides phénols présents dans les sols. Bull. de l'École Nationale Supérieure Agronomique de Nancy, IX, 73-92 (1967).

BURGES, A. and P. LATTER: Decomposition of humic acid by fungi. Nature 186, 4722, 404-405 (1960).

BURGES, A., H.M. HURST and S. B. WALKDEN: Nature of humic acids. Nature 199, 696 (1963).

BURGES, N.A., H.M. HURST and B. WALKDEN: The phenolic constituents of humic acid and their relation to the lignin of the plant cover. Geochim. Cosmochim. Acta 28, 1547-1554 (1964).

CHAMINADE, R.: Action de l'acide humique sur le développment et la nutrition minérale des végétaux. VI. Int. Soil Sci. Congr. Vol.D. Paris, 443 (1956).

CHAMINADE, R.: Effet physiologique des constituants de la matière organique des sols, sur le metabolisme des plantes, la croissance et le rendement. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press Ltd. Oxford 1966, 35-47.

CHAMINADE, R.: Rôle specifique de la matière organique sur la nutrition et le rendement des végétaux. Pontificial Academiae Scientiarum Scripta Varia 32, 777-804 (1968).

CHAKRABARTRY, S.K., B.K. MAZUMDAR, S.N. ROY and A. LAHIRI: Structural parameters of coal based on oxidation experiments. Brennstoff-Chem. 41, 5, 138 (1960).

CHENG, H.H. and L.T. KURTZ: Chemical distribution of added nitrogen in soils. Soil Sci. Soc. Amer. Proc. 27, 312 (1963).

CHESHIRE, M.V., P.A. CRANWELL, C.P. FALSHAW, A.J. FLOYD and R.D. HAWORTH: Humic Acid-2. Tetrahedron 23, 1669-1682 (1967).

CHOUDRI, M.B. and F.J. STEVENSON: Chemical and physicochemical properties of soil humic colloids. III. Extraction of organic matter from soils. Soil Sci. Soc. Amer., Proc. 21, 508-513 (1957).

CHRISTEWA, L.A.: Die stimulierende Wirkung der Huminsäuren auf die Lebenstätigkeit höherer Pflanzen und die Effektivität der Humindünger in südlichen Gebieten der Ukraine. SSR. Int. Soil Sci. Congr. Vol. II, Comm. II u. IV. Hamburg 46-55 (1958).

CHRISTEWA, L.A.: Theorie und Praxis der Humindüngeranwendung in der Ukraine. Der Internationale Torfkongress, UdSSR Leningrad (1963)(russ.).

CHRISTEWA, L.A.: Über die Einheitlichkeit des Wirkungsmechanismus physiologische aktiver Stoffe (russ.).
Ministerium für Landwirtschaft der UdSSR, Landwirtschaftliche Hochschule Dnjepropetrowsk, 6-9 (1965).

CHRISTEWA, L.A.: About the nature of physiologically active substances of the soil humus and of organic fertilizers and their agricultural importance. Pontificiae Academiae Scientiarum Scripta Varia 32, 702-721 (1968).

CHRISTEWA, L.A., K.I. SOLOCHA, R.L. DYNKINA, A.I. GOROVAYA and V.E. KOVALENKO: Effect of physiological active substances of soil humus and fertilizers on the transformation of nuclein acids, growth of plants and quality of the seeds. Studies about Humus. Trans. Int. Symp. "Humus et Planta IV" Prague, russ. 212-276 (1967).

CINCEROVA, A.: The effect of humic acid on transamination in winter wheat plants. Biol. Plant 6, 183-188 (1964).

COFFIN, D.E. and W.A. DELONG: Extraction and characterization of organic matter of a podzol B-horizon. 7th. Int. Congr. of Soil Sci. Madison, Wisc. USA Vol. II, 91-97 (1960).

DEUEL, H. and P. DUBACH: Decarboxylierung der organischen Substanz des Bodens. II. Nachweis von Uronsäuren . Z. Pflanzenernähr., Düng., Bodenkunde 82, 97-106 (1958 a).

DEUEL, H. and P. DUBACH: Decarboxylierung der organischen Substanz des Bodens. III. Extraktion und Fraktionierung decarboxylierbarer Humusstoffe. Helv. Chim. Acta 41, 1310-1321 (1958 b).

DEUEL, H., P. DUBACH and R. BACH: Decarboxylierung der organischen Substanz des Bodens. I. Decarboxylierung der gesamten Humusstoffe. Z. Pflanzenernähr., Düng., Bodenkunde 81, 189 (1958).

DIJK, van H.: Die Kationenbildung der Huminsäuren. 4. Torf-Kolloquium DDR - VR Polen, 1-3 (1967) (Rostock).

DINCHEV, D. and K. BADZOV: Bestimmung des pflanzenaufnehmbaren Stickstoffs durch agrochemische Methoden mit Hilfe des stabilen Isotops ^{15}N. - Agrochimica (in press).

DRAGUNOV, S.S., ZHELOKHOVTSEVA and E.I. STRELKOVA: A comparative study of soil and peat humic acids. Pochvovedenie (7), 409 (1948).

DUBACH, P. and N.C. MEHTA: The chemistry of soil humic substances. Soils Fertilizers XXVI, 293-300 (1963).

DUBACH, P., N.C. MEHTA and H. DEUEL: Extraktion von Huminstoffen aus dem B-Horizont eines Podsols mit ÄDTE. Z. Pflanzenernähr., Düng., Bodenkunde 95, 119-123 (1961).

DUBACH, P.,N.C. MEHTA and H. DEUEL: Schonende Extraktion von Huminstoffen und Isolierung der Fulvosäure-Fraktion aus verschiedenen Bodentypen. Z. Pflanzenernähr., Düng., Bodenkunde 102, 1-7 (1963).

ELIAS, H.G.: Ultrazentrifugen-Methoden. Beckman Instruments G.m.b.H., München, 2. Auflage 1961, S. 126.

ERDTMAN, H.G.H. and C.A. WACHTMEISTER: Phenoldehydrogenation as a biosynthetic reaction. Festschrift Prof. Dr. W. Stoll, 8. Jan. 1957, 144-165.

EVANS, L. T.: The use of chelating reagents and alkaline solution in soil organic matter extractions. J. Soil Sci. 10, 110-118 (1959).

EVANS, W.C., B.S.W. SMITH, R.P. LINSTEAD and J.A. ELVIDGE: Chemistry of the oxidative metabolism of certain aromatic compounds by microorganisms. Nature 168, 772-775 (1951).

FARMER, V.C. and R. I. MORRISON: Chemical and infrared studies on phragmites peat and its humic acid. Sci. Proc. Roy, Dublin Soc. Series A 1 , 85-104 (1960).

FARMER, V.C. and R.I. MORRISON: Lignin in Sphagnum and phragmites and in peats derived from these plants. Geochim. Cosmochim. Acta 28, 1537-1546 (1964).

FARMER, V.C., M.E.K, HENDERSON and J.D. RUSSELL: Reduction of certain aromatic acids to aldehydes and alcohols by Polystictus versicolor. Biochim. Biophys. Acta 35, 202-211 (1959).

FLAIG, W.: Zur Bildungsmöglichkeit von Huminsäuren aus Lignin. Holzforschung 9, 1-4 (1955).

FLAIG, W.: Zur Chemie der Huminsäuren und deren Modellsubstanzen. Vle. Congrès Internat. de la Science du Sol. Paris, 2, 471-478 (1956).

FLAIG, W.: Die Chemie organischer Stoffe im Boden und deren physiologische Wirkung. Verhandl. d. II. und IV. Komm. d. Internat. Bodenkundl. Ges., Hamburg, Vol. II (1958).

FLAIG, W.: Chemie der Humusstoffe. Suomen Kemistilehti A 33, 229-251 (1960 a).

FLAIG, W.: Comparative chemical investigations on natural humic compounds and their model substances. Sci. Proc. Roy. Dublin Soc. Ser. A 1, 4, 149 (1960 b).

FLAIG, W.: Zur Umwandlung von Lignin in Humusstoffe. Freiberger Forschungshefte A 254, 39-56 (1962).

FLAIG, W.: Über den Einfluß von Humusstoffen auf den Stoffwechsel der Pflanzen. Der internationale Torfkongress UdSSR Leningrad 1963.

FLAIG, W.: Chemische Untersuchungen an Humusstoffen. Z. Chem. 4, 253-265 (1964 a).

FLAIG, W.: Gedanken zur Nomenklatur der im Boden vorhandenen organischen Stoffe. 8th Internat. Congr. Soil Sci. Transaction, Vol. III, Bucharest-Romania, 389-399 (1964 b). Discussions regarding the terminology in the field of humus, 405-413.

FLAIG, W.: Action des produits de dégradation de la lignine surgle métabolisme végétal mecanisme possible de cette action. C.R. Hebd. des Séances de l'Academie d'Agriculture de France No. 17, 1118-1138 (1965).

FLAIG, W.: c) Humusstoffe.
Handbuch der Pflanzenernährung und Düngung. Bd. II: Boden und Düngemittel 1966, S. 282-458, Springer-Verlag Wien.

FLAIG, W.: Uptake of organic substances from soil organic matter by plant and their influence on metabolism. Pontificiae Academiae Scientiarum Scripta Varia 32, 723-770 (1968).

FLAIG, W.: Contribution à la connaissance de la constitution et de la synthèse des acides humiques. Extrait de "Sciences du Sol", Supplément au Bulletin de l'Association Française pour l'Étude du Sol, No 2,39-72 (1970).

FLAIG, W. and H. BEUTELSPACHER: Zur Kenntnis der Huminsäuren. II. Elekronenmikroskopische Untersuchungen an natürlichen und synthetischen Huminsäuren. Z. Pflanzenernähr., Düng., Bodenkunde 52, 1-21 (1951).

FLAIG, W. and H. BEUTELSPACHER: Physikalische Chemie der Huminsäuren. Landbouwkund.Tijdschr. 66, 306-336 (1954 a).

FLAIG, W. and H. BEUTELSPACHER: Investigations of humic acids with the analytical ultracentrifuge. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Vienna 1968, 23-30.

FLAIG, W. and Th. BREYHAN: Über das Vorkommen von Indolverbindungen in Schwarzerde-Huminsäuren. Z. Pflanzenernähr., Düng., Bodenkunde 75, 132-135 (1956).

FLAIG, W. and K. HAIDER: Reaktionen mit oxydierenden Enzymen aus Mikroorganismen. Planta Medica, Z.f. Arzneipflanzenforsch. 9, 123-139 (1961 a).

FLAIG, W. and K. HAIDER: Die Verwertung phenolischer Verbindungen durch Weißfäulepilze. Arch. Mikrobiol. 40, 212-223 (1961 b).

FLAIG, W. and K. HAIDER: Über die Beteiligung von Phenolen am Aufbau von Huminsäuren. - 9th International Congress of Soil Science Transactions III, 175-182 (1968).

FLAIG, W. and W. de JONG: Untersuchungen über die Wirkung von p-Benzochinonderivaten auf den aeroben und anaeroben Stoffwechsel der Hefe (Saccharomyces aerevisiae).
Arch. f. Mikrobiol. 37, 355-368 (1960 a).

FLAIG, W. and W. de JONG: Vergleich der Wirkung von Thymochinon und Thymohydrochinon mit der von 2,4-Dinitrophenol auf den Stoffwechsel der Hefe (Saccharomyces aerevisiae).
Arch. f. Mikrobiol. 37, 369-378 (1960 b).

FLAIG, W. and S. MOHTADI: Chemische Eigenschaften von Extrakten aus Rottestroh und deren Einwirkung auf den Trockensubstanzertrag von Keimpflanzen. Landbauforsch. Völkenrode 15, 63-64 (1965).

FLAIG, W. and H. RIEMER: Polarographische Untersuchungen zum Verhalten von Trihydroxytoluolen bei der Reaktion mit Glycin unter oxydierenden Bedingungen. Justus Liebigs ANNALEN DER CHEMIE 746, 81-85 (1971).

FLAIG, W. and Chr. SALFELD: UV-Spektren und Konstitution von p-Benzochinonen. Liebigs Ann. Chem. 618, 117-139 (1958).

FLAIG, W. and J.Chr. SALFELD: Zwischenstufen bei der Bildung von Huminsäuren aus Phenolen. Transactions Vol. II, 7th Internat. Congr. of Soil Science, Madison, Wisc. USA, 648-656 (1960 b).

FLAIG, W. and G. SCHMID: Über den Wirkungsmechanismus stoffwechselaktiver Substanzen. In: Eigenschaften und Wirkungen der Gibberelline, Symposium der Oberhessischen Gesellschaft für Natur- und Heilkunde, Naturwissenschaft. Abt. zu Giessen vom 1.-3. Dez. 1960, S. 25-27 (Herausg. R. Knapp). Springer-Verlag Berlin-Göttingen-Heidelberg 1962.

FLAIG, W. and G. SCHMID: Comparison of the effect of chemical compounds and low doses of radiation on plant metabolism. "Effects of low doses of radiation on crop plants". Technical Reports Series No. 64, International Atomic Energy Agency, Vienna 1966, 26-38.

FLAIG, W. and H.L. SCHMIDT: Über die Einwirkung von Huminsäuren auf das Wachstum einiger Penicilliumarten. Arch. Mikrobiol. 27, 1-32 (1957).

FLAIG, W. and G. SCHOLL: Hacia el conocimiento de los acidos huminicos. XVIII. Comunicacion "Influencias de la timohidroquinona sobre la economia del agua en plantas de interes agricola. Anales de Edafologia y Agrobiologia XIX, 251-259 (1960).

FLAIG, W. and H. SÖCHTIG: Einige Grundlagen zur Frage der Krümelbildung.- Landbauforsch. 7, 80-83 (1957).

FLAIG, W. and H. SÖCHTIG: Über die Wechselwirkung von Kaolinit und Polyanionen. -Z. Pflanzenernähr., Düng., Bodenkunde 87, 1 44-57 (1959).

FLAIG, W. and H. SÖCHTIG: Einfluß organischer Stoffe auf die Aufnahme anorganischer Ionen.- Agrochimica 6, 251-264 (1962).

FLAIG, W. and H. SÖCHTIG: Organische Verbindungen als Stickstoffquelle für die Ernährung der Pflanzen. - Anales de Edafologia y Agrobiologia XXVI, 801-828 (1967).

FLAIG, W., H. BEUTELSPACHER and H. SÖCHTIG: Humus als Kationenaustauscher. Kalium-Symposium 1954, 81-107.

FLAIG, W.,H. BEUTELSPACHER and H. SÖCHTIG: Tagungsberichte Nr. 13, Probleme der Krümelstabilitätsmessung und der Krümelbildung.- Deutsche Akad. d. Landbauwiss. zu Berlin, 225-244 (1958).

FLAIG, W., F. SCHEFFER and B. KLAMROTH: Zur Kenntnis der Huminsäuren. VIII. Zur Charakterisierung der Huminsäuren des Bodens. Z. Pflanzenernähr., Düng., Bodenkunde 71, 33-37 (1955).

FLAIG, W., U. SCHOBINGER and H. DEUEL: Umwandlung von Lignin in Huminsäuren bei der Verrottung von Weizenstroh. Chem. Ber. 92, 1973-1982 (1959).

FORSYTH, W.G.C.: The characterization of the humic complexes of soil organic matter. J.Agric. Sci. 37, 132-138 (1947 b).

FREUDENBERG, K.: Forschung am Lignin, Fortschr. Chem. org. Naturstoffe 20, 41 (1962).

FREUDENBERG, K.: Entwurf eines Konstitutionsschemas für das Lignin der Fichte, Holzforsch. 18, 3-9 (1964 a).

FREUDENBERG, K.: Ergänzung des Konstitutionsschemas für das Lignin der Fichte, Holzforschung 18, 166 (1964 b).

FREUDENBERG, K. and J.M. HARKIN: Ergänzung des Konstitutionsschemas für das Lignin der Fichte. - Holzforsch. 18, 166-168 (1964).

FREUDENBERG, K.and A.C. NEISH: Constitution and biosynthesis of lignin. Springer-Verlag Berlin-Heidelberg, New York 1968.

FREUDENBERG, K., J.M. HARKIN, H. NIMZ and H. RENNER: Chem. Commun. 1965, p. 224.

FREYTAG, H.E.: Über die Zersetzung von pflanzlichem Material im Boden und einige Erfahrungen in der Messung von 14 CO_2 mit einer Gas-Zählkammer.- Thaer-Archiv 10, 685-697 (1962).

FREYTAG, H.E. and H. IGEL: Ein Bericht über den Einsatz des ^{14}C bei respirometrischen Messungen in der Humusforschung. Zbl. Bakteriol. Parasitenkunde. Infektionskrankh. Abtl. II, 117, 525-531 (1964).

FRÖMEL, W.: Über Absorptionsspektren von Huminsäuren in Lösungen. Bodenkunde und Pflanzenernähr. 6, 93 -119 (1938 a).

FRÖMEL, W.: Über UV-Absorptionsspektren von Huminsäuren in Lösungen. Bodenkunde und Pflanzenernähr. 11, 129-144 (1938 b).

FRÖMEL, W.: Über Fulvosäuren. Bodenkunde und Pflanzenernähr. 25, 345-358 (1941).

FÜHR, F.: Untersuchungen zur Aufnahme von Kohlendioxid und Strohabbauprodukten durch die Pflanzenwurzel. Dissertation Bonn 1962.

FÜHR, F. and D.SAUERBECK: Über die Aufnahme und Translokation ^{14}C-markierter organischer Rotteprodukte bei Raphanus sativus. Z. Pflanzenernähr., Düng., Bodenkunde 105, 136 (1964).

FÜHR, F. and D. SAUERBECK: Die räumliche und chemische Verteilung durch die Wurzel aufgenommener organischer Rotteprodukte bei Daucus carota. - Z. Landw. Forsch. 19., Sonderheft 153-163 (1965).

FÜHR, F. and D. SAUERBECK: The uptake of straw decomposition products by plant roots. In: "The use of isotopes in soil organic matter studies". Report of the FAO/IAEA Technical Meeting. Oxford Pergamon Press Ltd. 73-83 (1966).

FÜHR, F. and D. SAUERBECK: The uptake of colloidal organic substances by plant roots as shown by experiments with ^{14}C-labelled humus compounds. Isotopes in plant nutrition and physiology. International Atomic Energy Agency, Vienna 1967, 317-328.

FÜHR, F. and D. SAUERBECK: Decomposition of wheat straw in the field as influenced by cropping and rotation. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Vienna 1968, 241-250.

FUKUZUMI, R., K. MINAMI and S. SHIBAMOTO: Metabolic products from aromatic compounds by the wood-rotting fungus "Polystictus sanguineus".II. Acetoacetic acid and a-ketoglutaric acid from the medium containing benzoic acids. J. Japan. Wood. Res. Soc. 5, 76 (1959).

GADET, R. and L. SOUBLES: Le bilan de l'azote dans les sols. - Experimentation de longue durée en cases lysimétriques et utilisation de l'isotope stable de l'azote 15 N.C.R.A. cad. Agric. 1962, 145-153.

GADET, R. and L. SOUBLES: Bilan apparent et bilan réel de l'azote minéral appliqué au sol mesure en cases lysimétriques avec utilisation de l'azote 15. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press Ltd. Oxford 1966, 297-305.

GALE, E. F.: The bacterial amino acid decarboxylases. Advan. Enzymol 6, 1-32 (1946).

GRABBE, K. and K. HAIDER: Z. Pflanzenernähr., Bodenkunde (1971) in press.

GRAHAM-BRUCE, I.J.: Ausorption of disulfoton by soil J. Sci. Fd. Agric. 18, 72-77 (1967).

GROSS, S.R., R.D. GAFFORD and E.L. TATUM: The metabolism of protocatechuic acid by Neurospora. J. Bio. Chem. 210, 781-796 (1956).

GUMIŃSKA, Z. and J. SULEJ: The effect of sodium humate and sodium versenate upon sprouting of seed. Bioletyn Institutu Howowli i Aklimatyzacji. Roslin Nr. 3 29 (1964).

HAIDER, K.: Untersuchungen über den mikrobiellen Abbau von Lignin. Zbl. Bakeriol., Parasitenk., Infektionskrankh. u. Hygiene 198, 308-316 (1966).

HAIDER, K., J.P. MARTIN: The role of microorganisms in the formation of humic acids. - In: Isotopes and radiation in soil organic matter studies. Proceedings of the Symposium on the use of isotopes and radiation in soil organic matter studies. Intern. Atomic Energy Agency, Vienna 1968, 188-195.

HAIDER, K. and J.P. MARTIN: Humic acid-type phenolic polymers from aspergillus sydowi culture medium. Stachybotrys spp. cells and autoxydized phenol mixtures. - Soil Biol. Biochem. 2, 145-156 (1970).

HAIDER, K., L.R. FREDERICK and W. FLAIG: Reactions between amino acid compounds and phenols during oxydation. - Plant and Soil XXII, 49-64 (1965).

HAMENCE, H.: The effects of organic manures on the auxin content of soils and the "auxin balanca" in soils. J. Soc. Chem. Ind. (London) 67, 277-281 (1948).

HANSEN, E.H. and M. SCHNITZER: Zn-dust destillation and fusion of a soil humic and fulvic acid. Soil Sci. Soc. Amer. Proc. 33, 29-36 (1969).

HARMS, H.: Untersuchungen zur Aufnahme von phenolischen Ligninspaltstücken durch die Wurzeln von Weizenkeimpflanzen. Dissert. Justus-Liebig-Universität Giessen (1967).

HARMS, H., H.SÖCHTIG and K. HAIDER: Untersuchungen zur Aufnahme und Umwandlung C^{14}-markierter Phenole durch die Pflanze. I. Aufnahme von C^{14}-carboxylmarkierter p-Hydroxy-benzoe-, Vanillin- und Syringasäure durch die Wurzeln von Weizenkeimpflanzen und Verteilung der Aktivität über die Pflanze. Plant and Soil XXXI, No. 1 129-142 (1969 a).

HARMS, H., H. SÖCHTIG and K. HAIDER: Untersuchungen zur Aufnahme und Umwandlung C 14-markierter Phenole durch die Pflanze. II. Die Umwandlung von p-Hydroxy-benzoesäure, Vanillinsäure sowie Syringasäure nach der Aufnahme durch die Wurzeln von Weizenkeimpflanzen.- Plant and Soil XXXI, No. 2, 257-272 (1969 b).

HARMS, H., H. SÖCHTIG and K. HAIDER: Aufnahme und Umwandlung von unterschiedlichen Stellungen C^{14}-markierter Phenolcarbonsäuren in Weizenkeimpflanzen.-Z. Pflanzenphysiologie 64, Heft 5, S. 437-445 (1971).

HAUCK, R.D.: N-Isotope distribution in nitrogen gas evolved from soil during denitrification. Possible application to N-transformation studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press Oxford 1966 , 447-456.

HAUCK, R.D. and D.R. BOULDIN: Distribution of isotopic nitrogen in nitrogen gas during denitrification. - Nature 191, 871 (1961).

HAUCK, R.D. and S. W. MELSTED: Some aspects of the problem of evaluating denitrification in soils.- Soil Sci. Amer. Proc. 20, 361 (1956).

HAUCK, R.D., S.W. MELSTED and P.E. YANKWICH: Use of N-isotope distribution in nitrogen gas in the study of denitrification. - Soil Sci. 86, 287 (1958).

HAYAISHI, O., M. KATAGIRI and S. ROTHBERG: Mechanism of the pyrocatecase reaction. J. Amer. Chem. Soc. 77, 5450-5451 (1955).

HENDE, A. van den: L'incorporation d'azote dans la matière organique du sol; Possibilités de l'utilisation de l'usage d'azote lourd N-15. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 319-327.

HENDERSON, M.E.K.: Release of aromatic compounds from birch and spruce sawdusts during decomposition by white-rot fungi. Nature (London) 175, 634-635 (1955).

HILLMANN, W.S. and A.W. GALSTON: Inductive control of indoleacetic acid oxidase activity by red and near infrared light. - Plant Physiol. 32, 129-135 (1957).

HOBSON, R.P. and H.J. PAGE: Studies on the carbon and nitrogen cycles in the soil. VII. The nature of the organic nitrogen compounds of the soil: "Humic" nitrogen. J. Agric. Sci. 22, 497-515 (1932).

HOCK, A.: Beziehungen zwischen Konzentration und Farbwerten von Huminsäurelösungen. Z. Bodenkunde und Pflanzenernähr., 7, 99-117 (1938 a).

HOCK, A.: Grundsätzliches bei Farbmessungen in Huminlösungen. Z. Bodenkunde und Pflanzenernähr., 7, 279-302 (1938 b).

HOLLECK, L. and D. BECHER: Untersuchungen über den Einfluß der Leitsalzionen auf die polarographische Reduktion aromatischer Nitroverbindungen in Acetonnitril und Dimethylformamid. J. electroanal. Chem. 4, 321-331 (1962).

HOLMBERG, B.: Thioglykolsäure als Ligninreagenz. Ing. Ventenskaps Akad. Handl. No. 131, 5-15 (1934).

HOLMBERG, B.: Hypobromite lignin. - Ber. 75, 1760-1764 (1942).

HORNER, L. and W. DÜRCKHEIMER: Zur Kenntnis der o-Chinone. XII. o-Chinone aus Brenzcatechin-Derivaten. - Z. Naturforsch. 14B, 741 (1959).

HÜSER, R.: Probleme zur biologischen Luftstickstoffbindung in Waldböden. Z. Pflanzenernähr., Düng., Bodenkunde 103, 220-226 (1963).

HÜSER, R.: Experiences with the ^{15}N tracer technique to estimate the microbial fixation of elementary nitrogen in the organic matter of forest soils. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 457-469.

ISHIKAWA, H., W.J. SCHUBERT and F.F. NORD: Investigations on lignins and lignification. XXVII. The enzymic degradation of softwood lignin by white-rot fungi. - Arch. Biochem. Biophys. 100, 131-139 (1963 a).

ISHIKAWA, H., W.J. SCHUBERT and F. F. NORD: Investigations on lignins and lignification. XXVIII. The degradation by Polyporus versicolor and fomes fomentarius of aromatic compounds structurally related to softwood lignin.- Arch. Biochem. Biophys. 100, 140-149 (1963 b).

ISHIKAWA, H., W.J. SCHUBERT and F.F. NORD: Investigations on lignins and lignification. XXX. Enzymic degradation of guajacolglycerol and related compounds by white-rot fungi. Biochem. Z. 338, 153-163 (1963 c).

JACQUIN, F.: Chromatographic study of various types of humic acids. C. R. hebd. Séances Acad. Sci. 250, 1892-1893 (1960).

JACQUIN, F.: Contribution à l'étude des processus de formation et d'évolution des divers composés humiques. Thèse Docteur des Sciences. Bull. ENSAN V, 1-156 (1963).

JANSSON, S.L.: Tracer studies on nitrogen transformations in soil.- Ann. Roy. Agr. Coll. Sweden 24, 101 (1958).

JANSSON, S.L.: Balance sheet and residual effects of fertilizer nitrogen in a 6-year study with N 15.- Soil Sci. 95, 31 (1963).

JANSSON, S.L.: Nitrogen transformation in soil organic matter. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting.- Pergamon Press. Ltd. Oxford 1966 a, 283-296.

JANSSON, S.L.: Experimental techniques with isotope-N 15. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting.- Pergamon Press. Ltd. Oxford 1966 b, 415-422.

JANSSON, S.L. and J. PERSON: Co-Ordination of humus chemistry and soil organic matter biology by isotope techniques. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Vienna 1968, 111-123.

JENKINSON, D.S. and J. TINSLEY: A comparison of the ligno-protein isolated from a mineral soil and from a straw compost. Sci. Proc. Roy Dublin Soc. A 1, 141-147. (1960)

JENKINSON, D.S.: The turnover of organic matter in soil. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966 a, 187-197.

JENKINSON, D. S.: The priming action. In: the use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press, Ltd. Oxford 1966 b, 199-208.

JENKINSON, D.S.: Experimental techniques for using carbon-14 in studies of soil organic matter. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966 c, 365-369.

JENKINSON, D.S.: Studies on the decomposition of plant materials in soil I-III. J. Soil Sci. 16, 104-115 (1965; 17, 280-302 (1966 b); 19, 25-39 (1968).

JONES, E.J.jr.: The ultraviolet absorption spectra of complex hydroxyaromatic compounds and derivatives, with particular reference to lignin. Tappi 32, 311-315 (1949).

KAILA, A.: Humification of straw at various temperatures. Acta agral. fenn. Helsinki 78, 3-32 (1952).

KASATOCHKIN, V.I. and O.I. ZILBERBRAND: X-ray and infrared spectroscopy applied to the study of the structure of humic substances. Pochvovedenie No. 5, 80-85 (1956).

KASATOCHKIN, V.I., M.M. KONONOVA and G.I. ZILBERBRAND: Infrarotspektren von Huminsäuren des Bodens. Dokl. Akad. Nauk 119, 785-788 (1958). (russ.).

KASTORI, R., H. HARMS, H. SÖCHTIG and K. HAIDER: Untersuchungen zur Aufnahme und Umwandlung C^{14}-markierter Phenole durch die Pflanze. III. Die Aufnahme, der Transport und die Umwandlung von C^{14}-markiertem Thymohydrochinon durch Weizenkeimpflanzen. Plant and Soil 33, 597-611 (1970).

KAUR-SAWHNEY, R., M. BARA and A. GALSTON: Analysis of labelling patterns in soluble RNA preparations from green pea stem sections supplied with ^{14}C-carboxyl-labelled indoleacetic acid.- Annals of the New York Academy of Sciences 144, Art. I. 63-67 (1967).

KILBY, B.A.: The bacterial oxidation of phenol to ß-ketoadipic acid. Biochem. J. 43, V (1948).

KILBY, B.A.: The formation of ß-ketoadipic acid by bacterial fission of aromatic rings. Biochem. J. 49, 671-674 (1951).

KLEIST, H. and D. MÜCKE: Stabile freie Radikale in Huminsäuren. Experientia 22, 136-137 (1966).

KOLENBRANDER, G.J.: Die Verluste an organischer Substanz im Stalldünger. Z. Pflanzenernähr., Düng., Bodenkunde 69, 125-134 (1955).

KONONOVA, M.M.: Humus der Hauptbodentypen der UdSSR, seine Natur und Bildungsweisen. Rapports VI. Congr. Internat. de la Science du Sol, Chemie du Sol, S. 5, Moskau (1956) (russ.).

KONONOVA, M.M.: Soil organic matter. Its nature, its role in soil formation and in soil fertility. Pergamon Press Oxford, London, New York, Paris (1961).

KONONOVA, M.M.: Gedanken zur Nomenklatur der im Boden vorhandenen organischen Stoffe. 8th Internat. Congr. of Soil Sci. Transaction, Vol. III, Bucharest-Romania, 401-404 (1964). Discussions regarding the terminology in the field of humus, 405-413.

KONONOVA, M.M.: Soil organic matter, its nature, its role in soil formation and in soil fertility. Pergamon Press, Oxford, London, Edinburgh, New York, Toronto, Sydney, Paris, Braunschweig (1966).

KONONOVA, M.M. and N.P. BELCHIKOVA: Rapid methods of determining the humus composition of mineral soils. Pochvovedenie (10), 75 (1961).

KRATZL, K. and P. CLAUS: Zur quantitativen Bestimmung der monomeren Äthanolysenprodukte aus dem Lignin monocotyler und dicotyler Angiospermen. Monatsh. Chem. 93, 219-229 (1962).

KRATZL, K. and E. RISNYOVSZKY: Zum Mechanismus der alkalischen Hydrolyse der Ligninsulfosäure. Chimie et Biochimie de la Lignine de la Cellulose et des Hémicelluloses. Actes du Symposium Internationanl de Grenoble, Juillet (1964),

KRATZL, K., G. BILLEK, E. KLEIN, K. BUTSCHER: Über das Verhalten von markiertem Coniferin in der verholzenden Pflanze. Monatsh. f. Chemie 88, 721-734 (1957).

KRATZL, K., E. RISNYOVSZKY, P. CLAUS and E. WITTMANN: Über den Mechanismus der alkalischen Hydrolyse von Guajacylglyzerin-β-guajacyläther-α-sulfosäure. I. Mitteilung, Modellversuche zur Fragmentierung der Ligninsulfosäure in alkalischem Medium. Holzforschung 20, 21-27 (1966).

KRATZL, K., W. SCHAFER, P. CLAUS J. GRATZL and P. SCHILLING, Zur Oxydation von ^{14}C-markierten Phenolen (Ligninmodellen) Mh. Chemie 98, 891-904 (1967).

KUMADA, K.: Studies on the colour of humic acids. Part. I. On the concepts of humic substances and humification. Soil Sci. and Plant Nutr, 11, 11-16 (1965).

KUMADA, K. and A. AIZAWA: The infra-red spectra of humic acids. Soil and Plant Food 3, 1 2-159 (1958).

KUMADA, K. and K. AIZAWA: The infra-red absorption spectra of soil components. Soil and Plant Food 4, 101-188 (1959).

KUMADA, K. and A. SUZUKI: Isolation of anthraquinone from humus. Nature (London) 191, 415-416 (1961).

KUO, L.H. and A.V. BARTHOLOMEW: On the genesis of organic nitrogen in decomposed plant residue. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press Ltd. Oxford 1966, 329-335.

KÜSTER, E.: Umwandlung von Mikroorganismen-Farbstoffen in Huminstoffe. Z. Pflanzenernähr., Düng., Bodenkunde 57, 51-57 (1952).

KÜSTER, E.: Beiträge zur Physiologie der Streptomyceten. VI. Congrès International de la Sci. du Sol. Paris 3, 67-72 (1956).

KYUMA, K.: A fractional precipitation technique applied to soil humic substances. Soil Sci. Plant Nutr. 10, 33-35 (1964).

LANTZ, R. and H. MICHEL. Action de l'ammoniaque en des amines primaires sur le benzène substitué en 1,3 et par des groupes amino ou hydroxyles, non substitués ou substitués. Bull. Soc. Chim. France 12, 2402-2408 (1961).

LAATSCH, W., L. HOOPS and O. BIENECK: Über Huminsäuren des Pilzes Spicaria elegans. Z. Pflanzenernähr., Düng., Bodenkunde 58, 258-268 (1952).

LAROCHE, J. and R. COMBELLES: Préparation et micro-analyse de composés marqués à l'azote 15. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 423-428.

LEMAIRE, F.: Influence of the organic matter on the phosphate nutrition of plants. Vortrag anläßlich des Symposiums Humus et Planta in Prag vom 18.-24. September 1967.

LEVESQUE, M. and M. SCHNITZER: Organo-metallic interactions in soils: 6. Preparation and properties of fulvic acid-metal phosphates. Soil Sci. 103, 183-190 (1967 b).

LIM, S.: Beiträge zur Aufklärung der Zusammenhänge zwischen dem mikrobiellen Abbau des Lignins und der Bildung von Humusstoffen. Dissertation der Rheinischen Friedrich Wilhelms-Universität Bonn (1965).

LITTLE, E.C.S.: An apparatus for the determination of carbon-14 in organic matter. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 371-374.

MacDONALDS, D.L., R.Y. STANIER, J.L. INGRAHAM: The enzymatic formation of ß-carboxymucconic acid. J. Biol.Chem. 210, 809-820 (1954).

MAEDER, H.: Chemische und pflanzenphysiologische Untersuchungen mit Rottestroh. Diss. Justus Liebig Universität Giessen (1960).

MARTIN, A.E. and R. REEVE: The extraction of organic matter from podzolic B-horizons with organic reagents. Chem. and Ind. 1955, 356.

MARTIN, A.E. and R. REEVE: Chemical studies on podzolic illuvial horizons. I. The extraction of organic matter by organic chelating agents. J. Soil Sci. 8, 268-270 (1957 a).

MARTIN, A.E. and R. REEVE: Chemical studies on podzolic illuvial horizons. II. The use of acetylacetone as extractant of translocated organic matter. J. Soil Sci. 8, 279-286 (1957 b).

MARTIN, A.E., P. DUBACH, N.C. MEHTA and H. DEUEL: Bestimmung der funktionellen Gruppen von Huminstoffen. - Z. Pflanzenernähr., Düng., Bodenkunde 103, 29-39 (1963).

MARTIN, J.P. and K. HAIDER: Phenolic polymers of Stachybotrys atra, Stachybotrys chartarum und Epicoccum nigrum in relation to humic acid-formation. Soil Sci. 107, 260-270 (1969).

MARTIN, J.P. and K. HAIDER: Microbial activity in relation to soil humus formation. Soil Science 111, No. 1, 54-63 (1971).

MARTIN, J.P., S.J. RICHARDS and K. HAIDER: Properties and decomposition and binding action in soil of humic acid synthesized by Epicoccum nigrum. Soil Sci. Soc. Amer. Proc. 31, 657-662 (1967).

MASON, H.S.: Chemistry of melanin. III. Mechanism of oxidation of 3,4-dihydroxyphenylalanine by tyrosinase. J. Biol. Chem. 172, 83-99 (1948).

MASON, H.S.: Mechanisms of oxygen metabolism. Advan. Enzymol. 19, 79-231 (1957).

MASON, H.S., W.L. FOWLKS and E.W. PETERSON: Oxygen transfer and electron transport by the phenolase complex. J. Amer. Chem. Soc. 77, 2914-2915 (1955).

MUSSO, H., U.V. GIZYCKI, H. KRÄMER and H. DÖPP: Über Orceinfarbstoffe. XXIV. Über den Autoxydationsmechanismus bei Resorcinderivaten. Chem. Ber. 98, 3952-3963 (1965).

MUSSO, H., U. GIZYCKI, U.I. ZAHORSZKY and D. BORMANN: Die Bildung von Hydroxy-Chinonen durch Addition von Phenolen an Chinone. Liebigs Ann. Chem. 676, 10 -20 (1964).

NEHRING, K. and R. SCHIEMANN: Untersuchungen zum Humusproblem. I. Mitt. Beiträge zur Kenntnis der Vorgänge bei der Rotte von Stallmist und Komposten sowie zur Kenntnis der Huminsäuren. Z. Pflanzenernähr., Düng., Bodenkunde 57, 97-113 (1952 a).

NEHRING, K. and R. SCHIEMANN: Untersuchungen zum Humusproblem. I. Mitt. Beiträge zur Kenntnis der Vorgänge bei der Rotte von Stallmist und Komposten sowie zur Kenntnis der Huminsäuren. 2. Teil Beiträge zur Kenntnis der Huminsäuren.-Z. Pflanzenernähr., Düng., Bodenkunde 57, 193-215 (1952 b).

NEHRING, K.: Untersuchungen an aus verschiedenen Bodentypen isolierten Huminsäuren. Z. Pflanzenernähr., Düng., Bodenkunde 69, 71-86 (1955).

NICOLAUS, R.A.: Biogenese der Melanine. Conf. VII Corso chim. Acad. naz. Lincei, Milano (1962).

NITSCH, J.P. and C. NITSCH: Phenolic compounds and plant growth. Ann.Physiol. végét. 4, 211-225 (1962).

NORMAN, A.G. and S.H. JENKINS: The determination of lignin. I. Errors introduced by the presence of certain carbohydrates. Biochem. J. 28, 2147-2159 (1934 a).

NORMAN, A.G. and S.H. JENKINS: The determination of lignin. II. Errors introduced by the presence of proteins. Biochem J. 28, 2160-2168 (1934 b).

NORMAN, A.G. and C.H. WERKMAN: The use of nitrogen isotope N 15 in determining nitrogen recovery from plant material decomposing in soil.- J. Amer. Soc. Agr. 35, 1023 (1943).

OBERLÄNDER, H.E. and K. ROTH: Transformation of ^{14}C-labelled plant material in soils under field condition. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Wien 1968, 251-264.

OGNER, G. and M. SCHNITZER: Chemistry of Fulvic Acid, a Soil Humic Fraction, and its Relation to Lignin. Canad. Journ. of Chem. 49, 1053-1063 (1971).

ORLOV , D.S. and N.M. GRINDEL: Spectrophotometric determination of the humus content in soil. Pochvovedenie Nr. 1, 112-122 (1967)(russ.)

ORLOV, D.S., O.N. ROZANOVA and S.G. MATYUKHINA: Infrared absorption spectra of humic acids. Pochvovedenie Nr. 1, 17-25 (1962) (russ.).

OSTWALD, W.: Kolloid Z. 7, 255 (1928).

OTTEY, L., E.L. TATUM: Protocatechuic acid oxidase of Neurospora. J. Biol. Chem. 223, 307-311 (1956).

OWENS, L.S.: Nitrogen movement and transformations in soils as evaluated by a lysimeter study utilizing isotopic nitrogen.- Soil Sci. Soc. Amer. Proc. 24, 372-376 (1960).

OXFORD, A.E.: Anti-bacterial substances from molds. V. The bateriostatic powers of the methyl ethers of fumigatin and spinulosin and other hydroxy-, methoxy- and hydroxy-methoxy-derivatives of toluquinone and benzoquinone. - J. Soc. Chem. and Ind. 61, 189-192 (1942 a).

OXFORD, A.E.: The chemical reactions occurring between certain substances which inhibit bacterial growth and constituents of bacteriological media. Biochem. J. 36, 438-444 (1942 b).

OXFORD, A.E. and H. RAISTRICK: Antibacterial substances from molds. IV. Spinulosin and Fumigatin, metabolic products of Penicillium spinulosum Thom and Aspergillus fumigatus Fresenius.- J. Soc. Chem. and Ind. 61, 128-129 (1942).

PEOVER, M.E. and J.D. DAVIES: Einfluß der Ionenassoziation auf die Polarographie der Chinone in Dimethylformamid.- J. electroanalyt. Chem. 6, 46-53 (1963).

PHILLIPS, M.: The chemistry of lignin. Chem. Rev. 14, 103 - 170 (1934).

PIRET, E.L., G. WHITE, H.C. WALTHER jr. and A.J. MADDEN jr.: Some physicochemical properties of peat humic acids. Sci. Proc. Roy. Dubl. Soc. A 1, 4, 69-79 (1960).

PLOETZ, Th.: Beiträge zur Ligninbestimmung mit starker Schwefelsäure. Cellulosechemie 18, 49-57 (1940).

PLOETZ, Th.: Polymere Chinone als Huminsäuremodelle. - Z. Pflanzenernähr., Düng., Bodenkunde 69, 50-58 (1955).

PLOTHO, O.v.: Die Humusbildung der Mikroorganismen. Z. Pflanzenernähr., Düng., Bodenkunde 51, 212 (1950).

PLOTHO, O.v.: Weitere Untersuchungen zur Humusbildung der Mikroorganismen. Z. Pflanzenernähr., Düng., Bodenkunde 55, 151-169 (1951).

POLICARD, A. and M. BESSIS: Sur un mode d'incorporation des macromolécules par la cellule, visible en microscope électronique: la rhophéocytose. C.R. Acad. Sci. 246, 3194-3197 (1958).

POSNER, A.M.: The humic acid extracted by various reagents from a soil. Part. I. Yield, inorganic components, and titration curves. J. Soil Sci. 17, 65-78 (1966).

POSNER, A.M., B.K.G. THENG and J.R.H. WAKE: The extraction of soil organic matter in relation to humification. 9th Internat. Congr. Soil Sci., Adelaide, Australia, Transaction III, 153-162 (1968).

PRAT, S. and F. POSPISIL: Humic acids with C^{14}. Biol Plantarum (Praha) 1, 71 (1959).

PRAT, S.: Distribution of the humic substance fractions in plants. Biol. Plantarum (Praha) 2, 308 (1960).

PRAT, S.: On permeability and the effect of humic substances on plant cells. 5th Int. Congr. Biochem. Moskau (1961).

PRAT, S.: Das Problem des Eindringens und der Einwirkung von Humusstoffen auf die Pflanzenzellen.-Intern. Congress of Peat, Leningrad (1963).

PRIDHAM, J.B. and M. SALTMARSH: The biosynthesis of phenolic glucosides in plants. Biochem. J. 87, 218-224 (1963).

RAPER, H.S.: Die Einwirkung von Tyrosinase auf Tyrosin. Fermentforschung 9, 206 (1927).

RAPER, H.S.: The aerobic oxidases.- Physicl.Rev. 8, S. 245-248 (1928).

REINHARDT, G.: Untersuchungen über die Einwirkung von Lignin und dessen Abbauprodukten auf das Wachstum und den Stoffwechsel von Pflanzen. Dissertation Universität Giessen 1961.

RIEMER, H.: Polarographische Untersuchungen über Beziehungen zwischen Struktur und Reaktivität bei Benzochinonen. Dissertation TU Braunschweig 1970 .

RITTER, G.J., R.M. SEBORG and R.L. MITCHELL: Factors affecting quantitative determination of lignin by 72 percent sulfuric acid method. Ind. Eng. Chem. Analyt. Edit. 4, 202 (1932).

ROCHUS, W.: Die unterschiedliche physiologische Wirkung verschiedener Huminstoffqualitäten.- Vortrag anläßlich der Tagung der Deutschen Bodenkundlichen Gesellschaft in Mainz vom 4.-9.9. 1967.

RUHEMANN, H.: Untersuchungen zur Auftrennung physiologisch aktiver Stoffe aus Lignin unter Anwendung von Radiokohlenstoff. Dissertation Th Braunschweig 1964.

RYPACEK, V.: Der Einfluß isolierter Humusstoffe auf einige physiologische Äußerungen der Pflanzenzelle.- Studies about Humus, Symposium Humus and Plant, Praha and Brno. 28. IX. - 6.X.1961, 235-243 (1962).

SAALBACH, E.: Zur Kenntnis der Huminsäuren, XIV. Mitt. Einfluß von Modellsubstanzen von Humusstoffen auf den Stoffwechsel von Getreide. Landw. Forsch. 9. Sonderheft 95-100 (1957).

SAALBACH, E.: Beitrag der Grundlagenforschung zum Problem der Strohdüngung. Landwirtsch. Forsch. 8, 83-84 (1958).

SALFELD, J. Chr.: Zum Reaktionsmechanismus der Purpurogallinbildung. Angew. Chem 69, 723-724 (1957).

SALFELD, J. Chr.: Fraktionierung eines Huminstoffpräparates mit wasserhaltigen Lösungsmitteln. Landbauforsch. Völkenrode 14, 131-136 (1964).

SALFELD, J. Chr.: Die Charakterisierung von Huminstoffen durch Differenzen-Spektrogramme. Mitt. Dtsch. Bodenkundl. Ges. 4, 289-290 (1965).

SALFELD, J. Chr.: Untersuchungen zur Klassifizierung der organischen Bodensubstanz. Mitt. Dtsch. Bodenkundl. Ges. 8, 133-135 (1968).

SALFELD, J. Chr.: Optical measurements on humic systems. Symposium Humus et Planta V, Prag (1971), 257-266).

SALFELD, J. Chr. and E. BAUME: Über die Oxydation von Pyrogallol und Pyrogallolderivaten. IV. Die Konstitution der Purpurogallincarbonsäure -(9). Chem. Ber. 97, 307-311 (1964).

SAUERBECK, D.: Zur Markierung von Pflanzen mit ^{14}C. Atompraxis 6, 221-225 (1960).

SAUERBECK, D.: Stability of recently formed humus compounds in soil. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Vienna 1968 b, 57-66.

SAUERBECK, D.: Die Umsetzung markierter organischer Substanzen im Boden in Abhängigkeit von Art, Menge und Rottegrad. Landwirtsch. Forsch. 21, 91-102 (1968 a).

SAUERBECK, D.: Comparison of plant material and animal manure in relation to their decomposition in soil. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Vienna 1968 c, 219-225.

SAUERBECK, D. and F. FÜHR: Experiences on labelling whole plants with carbon-14. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 391-399.

SAUERBECK, D. and F. FÜHR: Alkali extraction and fractionation of labelled plant material before and after decomposition - a contribution to the technical problems in humification studies. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agenca, Vienna 1968, 3-11.

SAUERBECK, D. and F. FÜHR: Die Umsetzung von markiertem Pflanzenmaterial im Boden unter Feldbedingungen. Mitt. Deutsche Bodenkundl. Gesellsch. 10, 174-177 (1970).

SAUERLANDT, W. and O. GRAFF: Die Strohdecke auf dem Ackerboden. - Landbauforsch. Völkenrode 9, 57-60 (1959).

SCHANEL, L.: Laccase activity and decomposition of lignin by white-rot fungi. CSc. Thesis, Fac. Nat. Sci. UJEP Brno, (1962) (Czech.).

SCHARPENSEEL, H.W.: Herstellung und Reinigung von tritiummarkierten Grau- und Braunhuminsäurepräparaten sowie von Tritium-Purpurogallin. - Z. Pflanzenernähr., Düng. und Bodenkunde 91, 131-146 (1960 a).

SCHARPENSEEL, H.W.: Untersuchungen mit radioaktiv markierten Huminsäuren und Vorstufen. 2. Teil.- Z. Pflanzenernähr., Düng. und Bodenkunde 91, 193-202 (1960 b).

SCHARPENSEEL, H.W.: Zur Herstellung von allseitig C-14-markiertem Pflanzen- und Huminsäurematerial.- Landw. Forschung 14, 42-48 (1961).

SCHARPENSEEL, H.W.: Labelling of soil organic matter. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966 a, 351-364.

SCHARPENSEEL, H.W.: Results and problems of radiocolumn chromatographic work with humic acids. In : The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966 b, 375-390.

SCHARPENSEEL, H.W.: Experimental techniques with tritium including the production of labelling materials apparatus required and costs involved. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966 c, 471-481.

SCHARPENSEEL, H.W. and W. ALBERSMEYER: Infrarotspektroskopische Untersuchungen an Huminsäuren, Huminsäureaufschlüssen und phenolisch-chinoiden Vergleichssubstanzen. Z. Pflanzenernähr., Düng., Bodenkunde 88, 3, 203-211 (1960).

SCHARPENSEEL, H.W. and H. BECKMANN: Untersuchung zur Kohlendioxid-Entbindung des Bodens. II. Teil. Spezielle Studien unter Verwendung radioaktiver Tracer.- Z. Pflanzenernähr., Düng., Bodenkunde 104, 110-119 (1964).

SCHARPENSEEL, H.W. and R. KRAUSSE: Aminosäureuntersuchungen an verschiedenen organischen Sedimenten, besonders Grau- und Braunhuminsäurefraktionen verschiedener Bodentypen (einschließlich C^{14}-markierter Huminsäuren). Z. Pflanzenernähr., Düng., Bodenkunde 96, 11-34 (1962).

SCHARPENSEEL, H.W. and K.H. MENKE: Radiochromatographie mit schwachen ß-Strahlen. 1. Mitt. Z. analyt. Chem. 180, 81-92 (1961 a).

SCHARPENSEEL, H.W. and K.H. MENKE: Radiochromatographie mit schwachen ß-Strahlen (^{35}S, ^{14}C, ^{3}H). 2. Mitt. Radiosäulenchromatographie mit Hilfe des Flüssigkeits- und Scintillations-Spektrometers. Z. analyt. Chem. 182, 1-10 (1961 b).

SCHARPENSEEL, H.W., E. KÖNIG and E. MENTHE: Infrarot- und Differential-thermo-Analyse an Huminsäureproben aus verschiedenen Bodentypen, aus Wurmkot und Streptomyceten. Z. Pflanzenernähr., Düng., Bodenkunde 106, 134-150 (1964).

SCHEFFER, F. and R. KICKUTH: Chemische Abbauversuche an einer natürlichen Huminsäure. I. Z. Pflanzenernähr., Düng., Bodenkunde 94, 180-188 (1961 a).

SCHEFFER, F. and R. KICKUTH: Chemische Abbauversuche an einer natürlichen Huminsäure. II. Z. Pflanzenernähr., Düng., Bodenkunde 94, 189-198 (1961 b).

SCHEFFER, F. and B. ULRICH: Lehrbuch der Agrikulturchemie und Bodenkunde. III. Teil. Humus und Humusdüngung 1, Enke Stuttgart, pp. 266 (1960).

SCHEFFER, F., O.v. Plotho and E. WELTE: Untersuchungen über die Bildung von Humusstoffen durch Actinomyceten. - Landwirtsch. Forsch. 1, 81-92 (1950).

SCHEFFER, F., W. ZIECHMANN and H. SCHLÜTER: Über die Sedimentation von Huminsäuren in der Ultrazentrifuge. Kolloid Z. 160, 1-7 (1958).

SCHLICHTING, W.: Die Beeinflussung der Nährstoffaufnahme durch Huminstoffe, Mitt. d. Dtsch. Bodenkundlichen Gesellsch. 8, 165-167 (1968).

SCHMID, G.: Bericht über die Tätigkeit der Forschungsanstalt für Landwirtschaft, Braunschweig-Völkenrode, 12-13, (1962), 13-14 (1963), 15 (1964).

SCHMID, G. and W. FLAIG: Pflanzenstoffwechsel und Wirkstoffe. Landbauforsch. 12, 51-56 (1962).

SCHNITZER, M.: The application of infrared spectroscopy to investigations on soil humic compounds. Canad. Spectroscopy 10, No. 5 121-127 (1965).

SCHNITZER, M. and J.G. DESJARDINS: Molecular and equivalent weights of the organic matter of a podzol. Soil Sci. Soc. Amer., Proc. 26, 362-365 (1962).

SCHNITZER, M. and J.G. DESJARDINS: Carboxyl and phenolic hydroxyl groups in some organic soils and their relation to the degree of humification. Can. J. Soil Sci. 45, 257-264 (1965).

SCHNITZER, M. and I. HOFFMAN: Thermogravimetry of soil humic compounds. Geochim. Cosmochim. Acta 29, 359-370 (1965).

SCHNITZER, M. and S.I.M. SKINNER: Organo-metallic interactions in soils: 1. Reactions between a number of metal ions and the organic matter of a podzol E_h-horizon. Soil Sci. 96, 86-93 (1963 a).

SCHNITZER, M. and S.I.M. SKINNER: Organo-metallic interactions in soils. 2. Reactions between different forms of iron and aluminium and the organic matter of a podzol B_h-horizon. Soil Sci. 96, 181-186 (1963 b).

SCHNITZER, M. and S.I.M. SKINNER: Organo-metallic interactions in soils: 3. Properties of iron- and aluminium-organic matter complexes, prepared in the laboratory and extracted from a soil. Soil Sci. 98, 197-203 (1964).

SCHNITZER, M. and S.I.M. SKINNER: Organo-metallic interactions in soils. 4. Carboxyl and hydroxyl groups in organic matter and metal retention. Soil Sci. 99, 278-284 (1965 a).

SCHNITZER, M. and S.I.M. SKINNER: The carboxyl group in a soil organic matter preparation. Soil Sci. Soc. Amer., Proc. 29, 400-405 (1965 b).

SCHNITZER, M., D.A. SHEARER and J.R. WRIGHT: A study in the infrared of high molecular weight organic matter extracted by various reagents from a podzolic horizon. Soil Sci. 87, 252-257 (1959).

SCHNITZER, M. J.R. WRIGHT and J.G. DESJARDINS: A comparison of the effectiveness of various extractants for organic matter from two horizons of a podzol profile. Can. J. Soil Sci. 38, 49-53 (1958).

SCHOBINGER, U.: Chemische Untersuchungen über die Umwandlung von Weizenstrohlignin im Laufe der Verrottung.- Dissertation, ETH Zürich (1958).

SCHREINER, O. and E. SHOREY: Chemical nature of soil organic matter. U.S. Dept. Agric. Bureau of Soils Bull. 74, 5-48 (1910).

SEIFERT, K.: Die chemische Veränderung der Holzzellwand-Komponenten unter dem Einfluß pflanzlicher und tierischer Schädlinge. II. Abbau von Pinus sylvestris L. durch Coniophora cerebella Pers. Holzforschung 16, 102-113 (1962).

SHMUK, A.A.: The chemistry of soil organic matter. Trudy kuban. s.-kh. Inst. 1, 2 (1924), (russ.).

SHMUK, A.A.: The chemical nature of soil organic matter. Byull. Pochvoveda 5-7 (1930), (russ.).

SHOREY, E.: Some organic soil constituents. U.S. Dept. Agric. Bureau of Soils Bull. 88, 5-41 (1913).

SIMONART, P. and J. MAYAUDON: Étude de la décomposition de la matière organique dans le sol au moyen de carbone radioactif. I. Cinétique de l'oxydation en CO_2 de divers substrats radioactifs. Plant and Soil 9, 367-375 (1958 a).

SIMONART, P. and J. MAYAUDON: Étude de la décomposition de la matière organique dans le sol au moyen de carbone radioactif. II. Décomposition du glucose radioactif dans le sol. B Répartition de la radioactivité dans l'α-humus. - Plant and Soil 9, 381-384 (1958 b).

SIMONART, P. and J. MAYAUDON: Étude des transformations de la matière organique du sol au moyen du carbone-14. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 245-258.

SIMONART, P., J. MAYAUDON and L. BATISTIC: Étude de la décomposition de la matière organique dans le sol au moyen de carbone radioactif. IV. Décomposition des pigments foliaires. Plant and Soil 11, 176-180 (1959).

SLYKE, D.D. van, D.A. MacFADYEN and P. HAMILTON: Determination of free amino acids by titration of the carbon dioxide formed in the reaction with ninhydrin. J. Biol. Chem. 141, 671-680 (1941).

SMIDOVA, M.: Über den Einfluß von Na-Humat auf die Oxydations-Reduktions-Prozesse in den Wurzeln von Winterweizenpflanzen.- Studies about Humus. Symp. Humus and Plant, Praha and Brn. 28.9. - 6.10. 1961.

SMITH, J.H.: Some inter-relationships between decomposition of various plant residues and loss of soil organic matter as measured with carbon-14 labelling. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 223-233.

SMITH, F.B., W.H. STEVENSON and P. E. BROWN: The production of artificial manures. Agr. Exp. Sta. Res. Bul. 126, (1930).

SNEATH, P.H.A.: The application of computers to taxonomy. J. Gen. Microbiol. 17. 201-226 (1957).

SÖCHTIG, H.: Zur Erfassung der bei der Strohrotte gebildeten Ligninabbauprodukte: Kennzeichnung durch UV-Spektren. Landbauforsch. Völkenrode 11, 13-15 (1961 a).

SÖCHTIG, H.: Inwieweit können Strohrotteprodukte das Pflanzenwachstum beeinflussen? Über Veränderungen von Ligninabbauprodukten. Landbauforsch. Völkenrode 11, 16-18 (1961 b).

SÖCHTIG, H.: Beeinflussung des Stoffwechsels der Pflanzen durch Humus und seine Bestandteile und die Auswirkung auf Wachstum und Ertrag. - Landbauforschung Völkenrode 14, 9-16 (1964).

SÖCHTIG, H.: Auftrennung von Huminstoffen durch Gelfiltration. Mitt. Dt. Bodenk. Ges. 4, 297-300 (1965).

SÖCHTIG, H.: Zur Fraktionierung von Humusstoffen durch Gelfiltration. 1. Mitt. Das Verhalten von anorganischen Ionen aus der Asche und den Lösungen von Humusstoffen auf Sephadex-Gelen. Landbauforsch. Völkenrode 16, 25-30 (1966).

SÖCHTIG, H.: Ein Pflanzentest zur Feststellung der Wirkung stoffwechselaktiver Substanzen, Methodik und Erfahrungen. Deutsch-Polnisches Torf-Kolloquium DDR-Polen in Rostock 1967.

SÖCHTIG, H.: Zur Charakterisierung von Humusstoffen durch Gelfiltration. Dtsch. Bodenkundl. Ges. 8, 137-140 (1968).

SÖCHTIG, H.: Über den Einfluß von N-Lignin auf die Nitrifizierung im Boden sowie den Ertrag und den Nitratgehalt der Pflanzen. - Qual. Plant. Mater. Veg. XX, 1-2, 137-150 (1970).

SÖCHTIG, H. and H. HARMS: Über den Einfluß von Torf auf Keimung und Anfangswachstum von Pflanzen.-Landw. Forsch. 26/II (1971).

SÖCHTIG, H. and J.Chr. SALFELD: Characterization of humic systems in a black earth-Griserde-morphosequence in the area of Hildesheim. Symposium Humus et Planta V, Prag 1971, 247-256.

SÖCHTIG, H., H. HARMS and K. HAIDER: Uptake and transformation of ^{14}C-labelled phenolic acids by wheat seedling. In: Isotopes and radiation in soil organic matter studies. Proceedings of the Symposium on the use of isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Vienna 1968, S. 531-540.

SØRENSEN, H.: Studies on the decomposition of ^{14}C-labelled barley straw in soil. Soil Sci. 95, 45-51 (1963).

SØRENSEN, H.: Formation of soil organic matter during decomposition of plant components. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 271-274.

SOWDEN, F.J. and H. DEUEL: Fractionation of fulvic acids from the B-horizon of podzol. Soil Sci. 91, 44-47 (1961).

SPRINGER, U.: 1. Farbtiefe und Farbcharakter von Humusextrakten in ihrer Abhängigkeit von der Alkalikonzentration, zugleich ein Beitrag zur Kenntnis der Humustypen.- Z. Pflanzenernähr., Düng., Bodenkunde 34, 1-14 (1934).

SPRINGER, U.: Der heutige Stand der Humusuntersuchungsmethodik mit besonderer Berücksichtigung der Trennung, Bestimmung und Charakterisierung der Huminsäuretypen und ihre Anwendung auf charakteristische Humusformen. Bodenkunde und Pflanzenernähr. 6, 312-373 (1938).

SPRINGER, U.: Stoffabbau und Humusaufbau untersucht an einem Strohmist und Strohligninmist (Laboratoriumsversuch). Prakt. Blätter f. Pflanzenbau u. Pflanzenschutz 21/22, 1-57 (1944/45).

SPRINGER, U.: Über Komposthuminsäuren aus verschiedenen pflanzlichen Ausgangsstoffen.- Z. Pflanzenernähr., Düng., Bodenkunde 69, 66-71 (1955).

SPRINGER, U., and A. LEHNER: Stoffabbau und Humusaufbau bei der aeroben und anaeroben Zersetzung landwirtschaftlich und forstwirtschaftlich wichtiger organischer Stoffe. I.Z. Pflanzenernähr., Düng., Bodenkunde 58, 193-231 (1952 a).

SPRINGER, U. and A. LEHNER: Stoffabbau und Humusaufbau bei der aeroben und anaeroben Zersetzung landwirtschaftlich und forstwirtschaftlich wichtiger organischer Stoffe. II. Z. Pflanzenernähr., Düng., Bodenkunde 59, 1-27 (1952 b).

SPRINGER, U. and F. SELSCHAB: Zur Kenntnis der bei der Kompostbereitung auftretenden stofflichen Veränderungen. Mit Ergebnissen eines dreijährigen Gefäßversuches. Bayr. Landw. Jahrbuch 38, 250-300 (1961).

STAHLER, R.Y. and J.L. INGRAHAM: Protocatechuic oxidase.- J. Biol. Chem. 210, 799-808 (1954).

STANIER, RIY.: Simultaneous adaption: A new technique for the study of metabolic pathways. J. Bact. 54, 339-48 (1947).

STANIER, R.Y. and J.L. INGRAHAM: Protocatechuic oxidase. J. Biol. Chem. 210, 799-808 (1954).

STEELINK, C.: Free radical studies of lignin, lignin degradation products and soil humic acids. Geochim. Cosmochim. Acta 28, 1615-1622 (1964).

STEELINK, C. and G. TOLLIN: Stable free radicals in soil humic acid. Biochim. Biophys. Acta 59, 25-34 (1962).

STEELINK, C., J.W. BERRY, A.HO and H.E. NORDBY: Alkaline degradation products of soil humic acid. Sci.Proc. Roy. Dublin Soc. Ser. A 1, 59-67 (1960).

STEINMETZ, A.: Modellversuche zur Beteiligung von Polyphenoloxydasen bei der Bildung natürlicher Huminsäuren. Dissertation TH Braunschweig (1956).

STEWART, B.A., L.K. PORTER and D.D. JOHNSON: Immobilization and mineralization of nitrogen in several organic fractions of soil.- Soil Sci. Soc. Amer. Proc. 27, 302 (1963).

STOKES, G.G.: On the theories of internal friction of fluids in motion and the equilibrium and motion of elastic solids.- Trans. Cambridge Phil. Soc. 8, 287 (1849).

STÖCKLI, A.: Über den Abbau von Lignin, Cellulose und Hemicellulose durch Pilze. Versuche mit Streumaterialien, Holz und Ligninsulfonsäure. Promotion ETH Zürich (1952).

SULLIVAN, J.D. and G.T. FELBECK: A study of the interaction of s-triazine herbicides with humic acids from three different soils.- Soil Sci. 106, No. 1, 42-52 (1968).

SUNDMAN, W., K. HARO : On the mechanism by which cyclolignanolyctic agrobacteria might cause humification. Finiska Kemists Med. 75, 11-118 (1966).

SVEDBERG, T.: Die Molekulargewichtsanalyse im Zentrifugalfeld. - Kolloid Z. 67, 2-16 (1934).

SWABY, R.: Soil organic matter.- 8th, 9th, 10th C.S.I.R.O. Annual Reports. Government Printers, Sydney. (1956-1958).

THENG, B.K.G. and A.M. POSNER: Nature of the carbonyl groups in soil humic acids. Soil Sci. 101, 191-201 (1967).

TINSLEY, J. and A. SALAM: Extraction of soil organic matter with aqueous solvents. Soils and Fertilizers 24, 81-84 (1961).

TOKUDOME, S. and I. KANNO: Nature of the humus of some Japanese soils. 9th Internat. Congr. Soil Sci., Adelaide, Australia, Transactions III, 163-173 (1968).

TRAYNARD, Ph. and A. EYMERY: Delignification par les solutions hydrotropiques. II. Etude des lignines hydrotropiques. Holzforschung 10, 6-11 (1956).

TRIPPETT, S., S. DAGLEY and D.A. STOPHER: Bacterial oxidation of protocatechuic acid. Biochem. J. 76, 9p (1960).

TROJANOWSKI, J., A. LEONOWICZ and B. HAMPEL: Exoenzymes in fungi degrading lignin. II. Demethoxylation of lignin and vanillic acid. Acta Microbiol. Polon. 15, 17-22 (1966).

TROJANOWSKI, J., A. LEONOWICZ and M. WOJTAS: Exoenzymes in fungi degrading lignin. III. The effect of peroxidase on veratric acid. Acta Microbiol. Polon. 15, 215-222 (1967).

TYURIN, I.V.: Die organischen Stoffe der Böden. Selchosgis Moskau (1937) (russ.).

WAKSMAN, S.A. and J.W. SMITH: Transformation of methoxyl group in lignin in the process of decomposition or organic residues by microorganisms. J. Amer. Chem. Soc. 56, 1225 (1934).

WAKSMAN, S.A. and F.G. TENNEY: The composition of natural organic materials and their decomposition in the soil. I. Methods of quantitative analysis of plant materials. Soil Sci. 24, 275-283 (1927 a).

WAKSMAN, S.A. and F.G. TENNEY: The composition of natural organic materials and their decomposition in the soil. II. Influence of age of plant upon the rapidity and nature of its decomposition - rye plants. Soil Sci. 24, 317-333 (1927 b).

WAKSMAN, S.A., F.C. TENNEY and R.A. DIEHM: The chemical and microbiological principles underlaying the transformation of organic matter in the preparation of artificial manures. J.A.S.A. 21, 533-545 (1929).

WALTERS, E.H.: The isolation of p-hydroxy-benzoic acid from soils. J. Amer. Chem. Soc. 39, (1917).

WELTE, E.: Zur Konzentrationsmessung von Huminsäuren. Z. Pflanzenernähr., Düng., Bodenkunde 74, 219-227 (1956).

WHITEHEAD, D.C.: Identification of p-hydroxybenzoic, vanillic, p-coumaric and ferulic acids in soils. Nature 202, 417-418 (1964).

WHITEHEAD, D.C. and J. TINSLEY: Extraction of soil organic matter with dimethylformamide. Soil Sci. 97, 34-42 (1964).

WIESEMÜLLER, W.: Untersuchung über die Fraktionierung der organischen Bodensubstanz. Albrecht Thaer Archiv 9, 419-436 (1965).

WILZBACH, K.E.: Tritium-labelleing by exposure of organic compounds to tritium gas.- J. Amer. Chem. Soc. 79, 1013 (1957).

WILZBACH, K.E.: IAEA Tritium Symposium paper TTS/83, Vienna (1961).

WINTER, A.G.: Untersuchungen über die Aufnahme von Penicillin und Streptomycin durch die Wurzeln von Lepidum sativum und ihre Beständigkeit in natürlichen Böden. Z. Bot. 40, 153 (1952).

WINTER, A.G., H. PREUSS and F. SCHÖNBECK: Untersuchungen über die Aufnahme organischer Substanzen durch die Wurzeln höherer Pflanzen. I. Phenolische Verbindungen. Naturwissensch. 46, 536-537 (1959).

WRIGHT, J.R. and M. SCHNITZER: Oxygen containing functional groups in the organic matter of the Ao and Bh-horizon of a podzol. 7th Internat. Congr. Soil Sci. Madison, Wisc. USA 2, 120-127 (1960).

WRIGHT, J.R. and M. SCHNITZER: An estimate of the aromaticity of the organic matter of a podzol soil. Nature 190, 4777, 703-704 (1961).

ZELLER, A., H.E. OBERLÄNDER and F. HIEMER: A growth chamber for raising ^{14}C-labelled plants. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 401-413.

ZELLER, A., H.E. OBERLÄNDER, K. ROTH and I. STADLER: The humification of carbon-14 labelled mycelium in soil. In: The use of isotopes in soil organic matter studies. Pergamon Press. Ltd. Oxford 1966, 275-279.

ZELLER, A., H.E. OBERLÄNDER and K. ROTH: A field experiment on the influence of cultivation practices on the transformation of 14C-labelled farmyard manure and 14C-labelled straw into humic substances. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Vienna 1968, 265-274.

ZENK, M.H.: Einbau von p-Hydroxybenzoesäure in die Hydrochinonkomponente des Arbutins in Bergenia crassifolia. - Z. Naturforsch. 19 b, 856-857 (1964).

ZIECHMANN, W.: Spectroscopic investigations of lignin, humic substances and peat. Geochim. Cosmochim. Acta 88, 1555-1566 (1964).

ZIECHMANN, W. and H. SCHOLZ: Spektroskopische Untersuchungen an Huminsäuren. Naturwissenschaften 47, 193-196 (1960).

ZIECHMANN, W.: Infrared spectra of humic acids. Brennstoff-Chem. 39, 353 (1958).

ZIECHMANN, W.: Die Darstellung von Huminsäuren im heterogenen System mit neutraler Reaktion. Z. Pflanzenernähr., Düng., Bodenkunde 84, 155-159 (1959).