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Lignin Transformation in Forest Litter

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Introduction

Lignin is one of the most stable organic substances, that, being the components of plant residues, find their way to the surface of forest soils. Process of lignin transformation in the soil litter is a part of carbon cycling in forest ecosystems and may result, in particular, in formation of more biochemically stable organic polymers - humic substances (Kononova 1966). Layers of the forest litter, changing in vertical direction, represent a natural chronosequence (in the time interval from 0 to n·100 years) of different stages of transformation of the initial organic material.

The purpose of the present work was to study chemical properties of the lignins, obtained from different layers of the forest litter, in order to observe the fate of lignin during process of transformation of organic residues in soil.

Materials and methods

Lignins were obtained from L, F1, F2, F3, FH layers of the litter of podzol soil of south boreal zone of European Russia using a Klason method (Brauns and Brauns 1960) and by extraction with dioxane (Bambalov 2000). For obtained samples of „klason-lignins" (KL) and „dioxane-lignins" (DL) elementary composition, absorption in IR- and visible (E_{465}) region were determined. Molecular weights of the lignins were obtained by gel-filtration. Total acidity and content of carboxylic groups were determined by potentiometric titration. Properties of the lignins were compared with those of humic acid (HA), extracted from litter with 0.1M NaOH.

Results and discussion

When using Klason method for isolating lignin from litter, the products obtained may contain, together with proper lignin and products of its modification, considerable amount of humic substances, which are formed in the litter. Whereas, extraction with dioxane, used in the present work, allowed to obtain the most unmodified and pure lignin, with the yield about 4-8% of KL content (Table 1).

Layer	Lignin content, %	E_{465}	E_{465}/E_{665}	Total acidity, mM(-)/g	COOH, mM(-)/g
Klason-lignins					
L	60.3	0.124	10.6	5.0	1.6
F1	60.6	0.113	11.7	4.8	2.8
F2	60.0	0.043	4.9	4.0	2.0
F3	87.5	0.067	7.1	3.9	2.5
FH	91.1	0.070	6.8	3.1	2.8
Dioxane-lignins					
L	4.2	0.025	5.9	2.7	1.3
F1	2.6	0.026	5.7	2.6	0.9
F2	2.7	0.024	5.0	2.3	0.9
F3	2.8	0.027	5.7	2.5	1.1
FH	6.9	0.028	4.9	2.2	1.0

Table 1. Chemical properties of lignins obtained from litter layers

As shown in Table 1, there were distinct differences in properties of KL and DL samples. Elementary compositions of KL and DL were also unlike (for KL mean C content was 39.1%, H–38.8, O–21.9, N–0.2%; for DL – 35.9, 51.6, 12.7, 0.2%, respectively). Chemical properties of KL from the different litter layers changed considerably (Table 1), whereas for DL no significant changes were observed (with the exception for methoxylic groups content, which decreased with the depth of the litter, according to IR-spectroscopy data). KL were found to be more similar in their properties to the humic acids, extracted from corresponding layers of the litter, than DL. According to gel-filtration, DL, KL and HA were found to consist of 3 molecular fractions with molecular weights >150, 60 and 10kDa. For DL 60kDa fraction prevailed (42-54%). KL and HA consisted mostly of 10kDa fraction (84-89 and 77-83%, respectively), whereas content of 60kDa fraction in this two groups of samples was insignificant (10-15%). It was found, that treatment with dioxane completely removed 60kDa fraction from preparations of purified humic acids.

Conclusion

The obtained results indicate, that fraction of the relatively unchanged lignin may probably occur in decomposing organic matter of the litter layers of different age. This fraction may be incorporated as mechanical admixture into humic substances, extracted from the soils with alkali, and changes their physico-chemical properties.

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