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LUMINESCENT PROPERTIES OF NATURAL SUBSTANCES IN SOLUTIONS UNDER LOW-DOSE RADIATION EXPOSURE

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Object

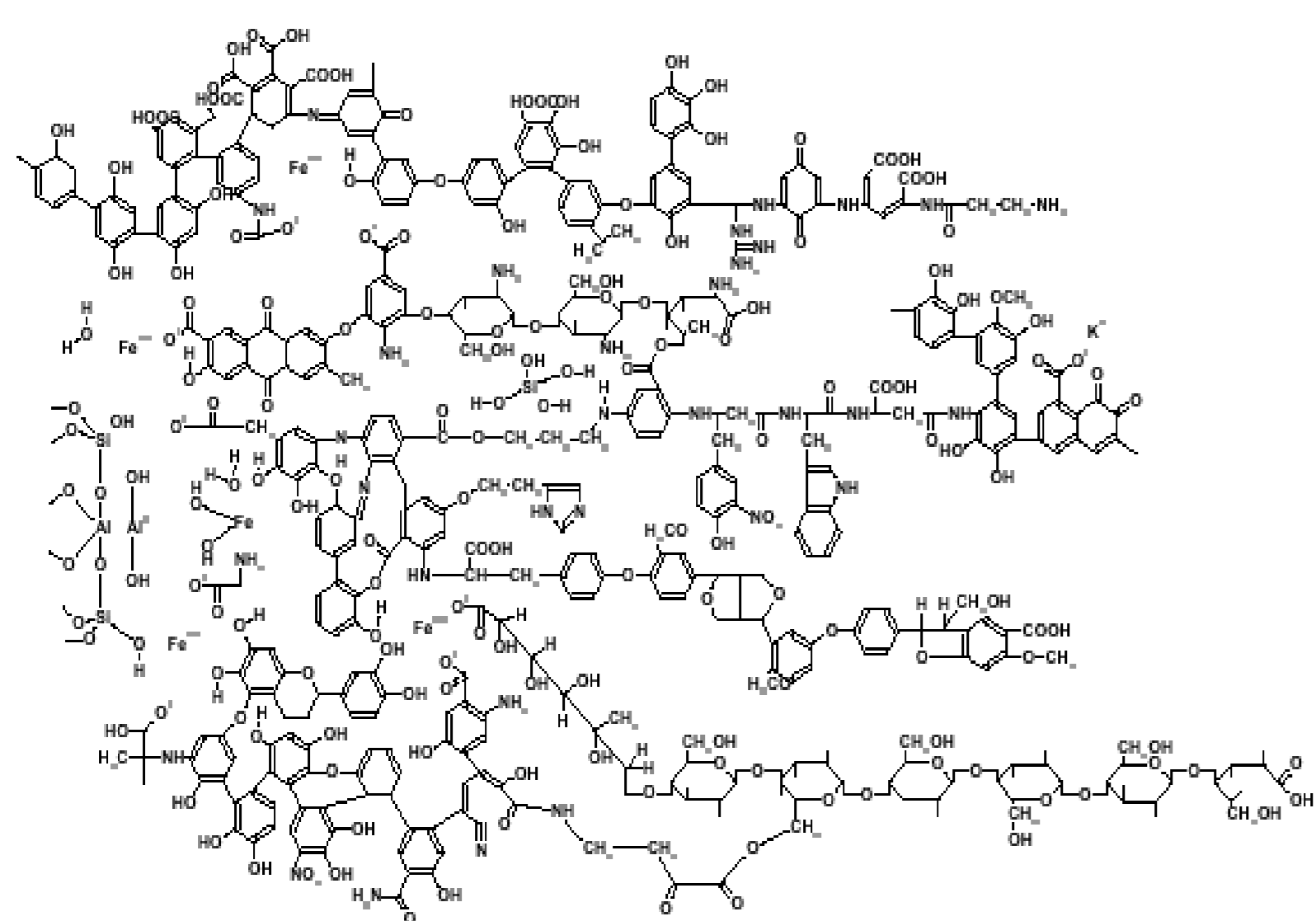


Fig. 1. Humic acids (HS)

The relevance of the research

Promising biologically active agents of natural origin are humic substances (or natural organic materials, fig.1). These compounds are widely distributed in natural waters and soils, and have a wide range of chemical and physical properties. Their structure includes a large number of diverse functional groups, which determines their complex-forming, surface-active and redox properties, as well as contributes to their biological activity and possess detoxifying properties. Using humic substances, it is possible to reduce the toxicity of an important class of toxicants - radionuclides. Technogenic pollution by radioactive elements is a consequence of the extraction and processing of radioactive materials, the operation of nuclear power stations, the placement of radioactive waste, accidents at nuclear enterprises, etc. [1-3].

1. S. Tarasova, E. S. Kovel, G. N. Churilov, D. I. Stom, N. S. Kudryasheva, "Biological activity of carbonic nano-structures - comparison via enzymatic bioassay", Journal of Soils and Sediments, vol. 19, no. 6, pp. 2689–2696, 2019.
2. O. N. Tchaikovskaya, L. V. Nechaev, N. V. Yudina, E.V. Mal'tseva, "Quenching of fluorescence of phenolic compounds and modified humic acids by cadmium ions", Luminescence (Wiley InterScience), vol. 31, pp. 1098–1102, 2016.
3. L. V. Nechaev, O. N. Tchaikovskaya, "Investigations of the effect of humic acids on phototransformation of naphthalene illuminated by visible and UV light", Russian Physics Journal, – Vol. 58, no. 12, pp. 1771–1774, 2016.

Spectral-luminescent properties

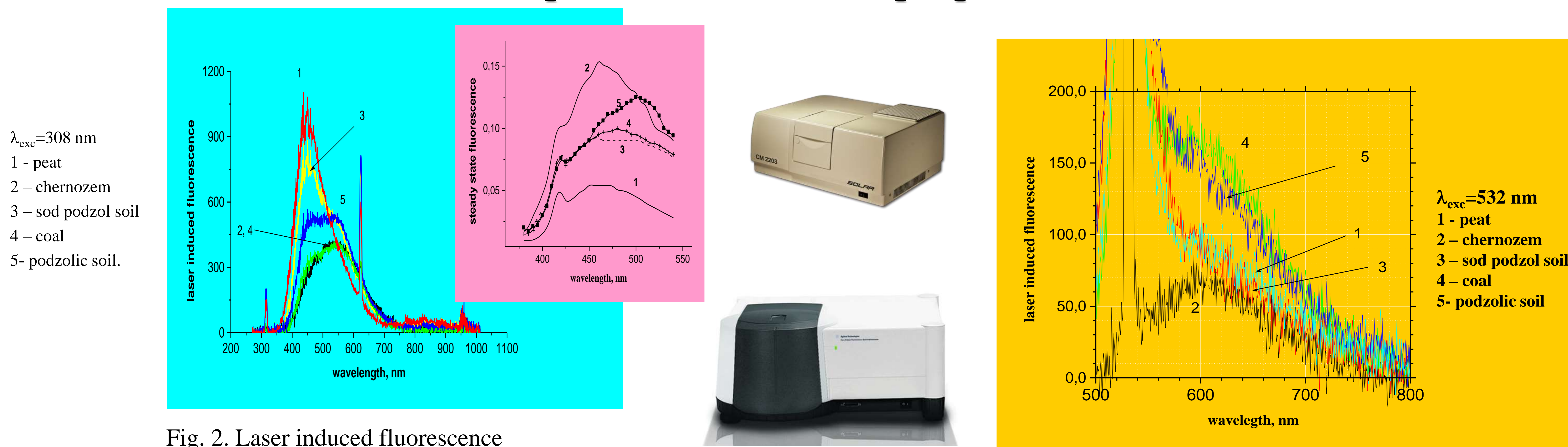
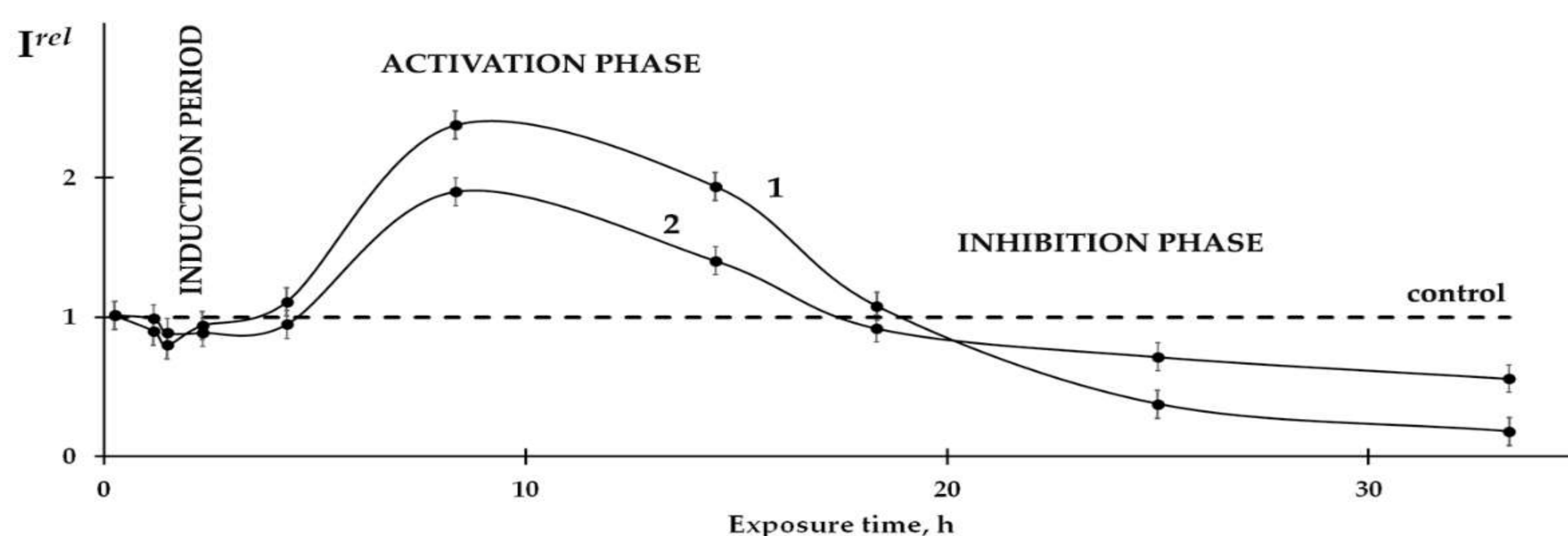


Fig. 2. Laser induced fluorescence monitoring of humic acids

Bioeffects of humic acids



Relative bioluminescence intensity of luminous bacteria (I^{rel}) vs. time of exposure to Am-241. 1 – absence of HS, 2 – presence of HS. Activity concentration of Am-241 solution 3 kBq/L [Rozhko, T.; Bondareva, L.; Mogilnaya, O.; Vydryakova, G.; Bolsunovsky, A.; Stom, D.; Kudryasheva, N. Detoxification of AM-241 solutions by humic substances: bioluminescent monitoring. Anal. Bioanal. Chem. 2011, 400, 329–334, doi:10.1007/s00216-010-4442-9.].

Bioeffects of HS in highly diluted solutions of alpha-emitting radionuclide americium-241 were studied. Luminous marine bacteria were applied as a biotest object; their bioluminescence intensity was considered as a bacterial physiological parameter. Curve 1 demonstrates a low-dose effect of americium-241 on the bacteria; it corresponds to "hormesis" toxicological model: the activation and inhibition stages are evident. The addition of HS did not change a type of the kinetic curve, but changed the bioluminescence intensity, decreasing its deviations from the control (non-irradiative) samples. Hence, HS mitigate the response of the bacteria to alpha-emitting radionuclide americium-241.

Results

The mass of the balls loaded into one crushing cylinder was 0.2–0.5 kg, the sample weight was 15–20 g, and the milling time was 2 min. Spectral-luminescent properties were obtained on a SM2203 spectrophotofluorimeter (Solar) in thorium nitrate solutions. Detection of the detoxifying effect of humic acids in model solutions of emitting radionuclides (thorium-232) was studied under conditions of low-dose radiation exposure. In the work, the dependences of the toxic effect of tritium on luminescent bacteria were estimated. The effectiveness of detoxification with humic acids in solutions of various radionuclides (thorium - 232 and tritium) has been established.