Humics-Based Chemicals and Materials Designed for Ecoadaptive Chemistry and Technology

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Humic substances (HS) are abundant in the environment. They penetrate through water, soil, and air. They have plentiful fossil and renewable resources including oxidized brown coal, peat, sapropel, spent sulphite liquor, composts, and other organic waste. HS govern many vitally important ecosystem processes like maintenance of soil fertility, nutrients delivery to plants, mitigation of abiotic stresses, etc. Numerous examples on their beneficial effects to plants and other living organisms are reported. Still, due to complexity of humic molecular assemblies, they have been very limitedly tapped for practical needs. Here we introduce a concept of ecoadaptive chemistry, which implies molecular and functional studies of life-sustaining processes in nature aimed at their further transfer into ecoadaptive technologies via rational design of nature-like chemicals, materials, and processes (Perminova 2019). We show how the disclosed mechanisms of self-purification and self-healing implied by natural systems can be applied to molecular design of humics-based products (chemicals, materials) with the tailored properties. The examples will be given for direct chemical modification of HS by incorporation of phenolic units into molecular backbone of HS, for preparation of interpolyelectrolyte complexes with aminoorganolanes, for HS assisted synthesis of nanoparticles with the needed properties (iron (hydr)oxides, silver, gold), for preparation of HS-based hybrid nanomaterials. The possibilities for practical applications of the obtained humic derivatives, polyelectrolyte complexes, HS-stabilized nanoparticles and hybrid materials will be demonstrated. They include novel humics-based biocatalytic systems for manipulation of microbial metabolism (suppression of methane synthesis by methanogens), solid HS-clay emulsion stabilizers for eliminating of oil slicks, humics-based non-lactam inhibitors of beta-lactamases, HS-based nanomaterials for wound-healing. The developed approaches open a way for broad innovative applications of humics-based chemicals and materials both in the field of environmental protection, biotechnology, human and environmental health. They also contribute to further elaboration and development of the concept of ecoadaptive chemistry and technology.

References

Perminova, I.V. From green chemistry and nature-like technologies towards ecoadaptive chemistry and technology. *Pure and Applied Chemistry* 2019, 91(5), 851-864. DOI: 10.1515/pac-2018-1110

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