Particles size organization and effect of solution of humic acid with LaVO4:Eu^{3+} nanoparticles on seed germination

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Abstract - By dynamic light scattering and transmission electron microscopy detected nanosized particles and large aggregates in humic solutions that re-distribute after adding nanoparticles accompanied by the emergence of nanoparticles cluster stabilized by humic hydrogel structure. The size organization of humic acid solution and nanoparticles has a more high effect on seed germination.

Keywords – humic acid, nanoparticles, particle size, aggregation, biological effect

Introduction

Humic solutions is a non-equilibrium complex polydisperse and dissipative system with multilevel organizations. It is represented by a set of individual biomolecule mixes, supramolecular aggregates (self-organized heterogeneous small and low-weight biomolecules, with conformation stabilization by weak forces) and micellar-like ensembles formed by intermolecular aggregation that determines the level of scale-structural organization of particles size, charge, polydispersity (PDI) [1]. Changes in conformations and level of structure and size organization in HA solutions occur in different biological effects of solutions on seed germination and root growth. [2]. The study aims to indicate a change in particles size organization with biological effect on morphometric parameters germinated seeds of wheat of alkali humic solutions (80 mg dry humic powder diluted 0.1 N NaOH) with LaVO4:Eu^{3+} nanoparticles (rod shape and size 60 nm, the doze of 0,33 g\L) mixed in equal proportions.

Results and discussion

The particle size distribution (PSD) of studied solutions is represented by a nanofraction of about 100 nm, a subfraction of about 200–700 nm and a macrofraction of more than 1000 nm (fig 1). Adding NP in the HA solution resulted in the appearance of subfraction with negative ζ-potential (from -27 to -39 mV) and a decrease of particles PDI. Also, an increase in the volume of nano-sized fractions in the solution of HA with NP is observed.

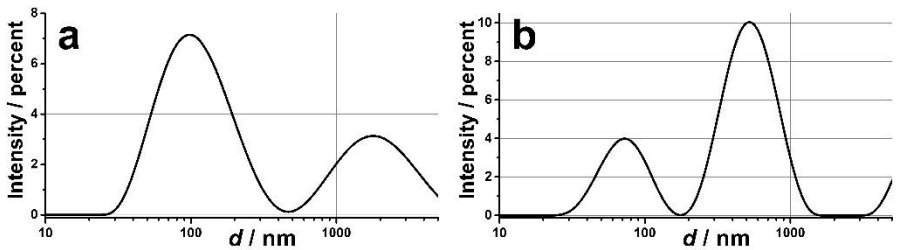

Fig. 1. Result of PSD by the intensity of HA solutions (a) and HA solution with nanoparticle (b)

Transmission electron microscopy (TEM) at 50 000x results of studied HA and HA+NP solutions present in fig 2 where can see humic nano-colloids spheroid (nanofractions) aggregate into more large agglomerate (sub- and macrofractions) with hydrogel-like stabilized structure (fig 2, b). Observed aggregation of NP in clusters agglomerates by absorption of organic hydrogel

structure on NPs surfaces that due to re-organization by intermolecular re-aggregation of large humic agglomerates (sub- and macrofraction).

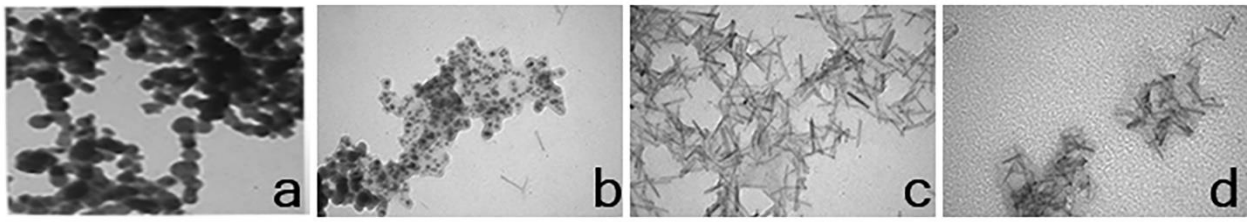

Fig 2. TEM images of HA solution (a) with rods NP (b), aggregate HA+NP agglomerate (c, d)

As can be seen in fig 3, the most pronounced biological effect of the solutions was observed by solution HA + NP was treated, they turned out to be more effective than HA and NP solutions and the roots were more sensitive than shoots. Treatment with the solution of HA+NP promoted deeper root growth and root structure development. When treated with solutions HA+NP, root length increased by 30% and 26% and shoot length by 31% and 19% compared to control. The highest biological effect of HA+NP solution on seed germination can be occurred of higher antioxidant properties by increasing the activity of functional humic groups through NP effect on size re-distribution and conformational re-organization of supramolecular aggregates.

Fig 3. Effect of solutions (from left to right plant pair: distilled water, solution of HA, solution of NP and solution HA+rods NP) on germinated wheat seed

Conclusions

Via TEM and DLS indicate a change in particles organization and colloid stability of humic solutions after adding NP that is accompanied by the re-distribution ratio of sized-fractions due to intermolecular re-aggregation of large humic agglomerate and emerging of NP cluster aggregate stabilized by absorbed hydrogel structure of HA. These particles size re-organization in HA+NP solution can be accompanied also by a conformational change of humic particles and supramolecular aggregates that expressed in high biology effect on germination seed of wheat. These results can be useful for developing a more effective hybrid functional material of natural organic with engineered nanomaterial.

References

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