

Mr. McMurry,

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At the February meeting, the similarity in syntax between the terms for the various humic substances and the terms for the various salts of the maleic-itaconic copolymers was noted, but the chemical and functional similarities between humic acids, fulvic acids, and the acidic maleic-itaconic copolymer were not adequately discussed as evidenced by the gentleman from Idaho's comments and questions.

Briefly:

- Humic acids and fulvic acids are biologically derived polydisperse anionic polymers with a charge density of 400-900 meq/100g.
 - Humic/fulvic acids benefit phosphate availability in soil through: competition for phosphate binding sites on metal oxides; modification of the precipitation patterns of insoluble phosphate salts, by sequestration of antagonistic metals ions that precipitate as insoluble phosphates, and through solubilization of insoluble phosphate salts present in the soil (Urrutia 2013, attached).
- The maleic-itaconic copolymers are synthetically derived polydisperse anionic polymers with a charge density of 1800 meq/100g.
 - Maleic-itaconic copolymers benefit phosphate availability in soil through: competition for phosphate binding sites on metal oxides (Doydora 2017, previously submitted); modification of the precipitation patterns of insoluble phosphate salts (Mooso, Tindall, both previously submitted); sequestration of antagonistic metals ions that precipitate as insoluble phosphates; and solubilization of insoluble phosphate salts (Doydora 2017, previously submitted).
- Natural and synthetic materials rich with metal binding capacity (compounds possessing carboxylic, phenolic, or sulfonic moieties) were tested by BFGoodrich as inhibitors of amorphous calcium phosphate precipitation under highly supersaturated conditions (Amjad 2005, attached).
 - The results of this test were, in decreasing order of effectiveness, Polyacrylic Acid >> Fulvic Acid > Tannic Acid > Green Tea Extract > Lignonsulfonate. Here consider polyacrylic acid to be an analog of the maleic itaconic copolymer albeit with only one carboxyl group per monomer v. two carboxylates per each monomer incorporated into the copolymer.
- In a published study (Ord 1991, attached), purified naturally sourced humic and fulvic acids were found to decrease the urease's reaction (decreased Vmax) rate in a concentration and pH dependent manner. These natural polyanionic polymers also reduced the enzyme's affinity for its substrate (increased Km) in a non-concentration dependent fashion. These investigators synthesized model humic and fulvic acids to eliminate ash and nitrogenous impurities in the naturally derived humic and fulvic as influencers of urease activity. These model compounds—free of ash and nitrogen—were equally effective as the natural humic and fulvic acids. The model fulvic acid chosen for this study was polymaleic acid, a close congener of the maleic-itaconic copolymer.

It is my sincere hope that these summary points create a clearer picture regarding the structure and function of the copolymer products.

With best regards,

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Director of Regulatory & Project Management