Building Block Syntheses of Gallic Acid Monomers and Tris-(O-gallyl)-gallic Acid Dendrimers Chemically Attached to Graphite Powder: A Comparative Study of Their Uptake of Al (III) Ions

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Abstract

A synthesis of graphite powder covalently modified with gallic acid (3,4,5-trihydroxybenzoic acid), via a 1,2-diaminoethane "linker" molecule, to form gallylaminoethylaminocarbonyl graphite (gallic-carbon) is reported. The synthesis was used as a model for a "ground-upwards building-block" approach to a primary dendrimer of gallic acid covalently attached to the surface of graphite powder, tris-(O-gallyl)-gallylaminoethylaminocarbonyl graphite (TGGA-carbon). The resulting modified carbon materials were characterized at each stage of the syntheses using X-ray photoelectron spectroscopy (XPS) analysis. The effects of increasing the modifier's structural complexity from monomeric gallic-carbon to the analogous primary dendrimer TGGA-carbon were explored by comparing each material's efficacy toward the adsorption of Al(III) ions from water. The uptake of Al(III) ions by gallic-carbon and TGGA-carbon was measured using UV−vis spectroscopy. In comparison to the case of monomeric gallic-carbon, the rate of adsorption of Al(III) ions by the TGGA-carbon was found to be 2.3 times more rapid. Furthermore, the total uptake of Al(III) ions was greater (reducing the concentration of 1000 ppb Al(III) solutions to below the WHO legal limit of 100 ppb in less than 5 min) and irreversible, in contrast to the gallic-carbon where the adsorption was found to be under thermodynamic control and to follow a Freundlich isotherm.