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Green-Synthesized β-Cyclodextrin Membranes for Humidity Sensors

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Abstract : Currently, the economic interests linked to the development of bio-based materials make biomass one of the most interesting areas for science development. We are interested in the β-cyclodextrin (β-CD), one of the popular bio-sourced macromolecule, produced from the starch via enzymatic conversion. It is a cyclic oligosaccharide formed by the association of seven glucose units. It presents a rigid conical and amphiphilic structure with hydrophilic exterior, allowing it to be water-soluble. It has also a hydrophobic interior enabling the formation of inclusion complexes, which support its application for the elaboration of electrochemical and optical sensors. Nevertheless, the solubility of β-CD in water makes its use as sensitive layer limit and difficult due to their instability in aqueous media. To overcome this limitation, we chose to precede by modification of the hydroxyl groups to obtain hydrophobic derivatives which lead to water-stable sensing layers. Hence, a series of benzylated β-CDs were synthesized in basic aqueous media in one pot. This work reports the synthesis of a new family of substituted amphiphilic β-CDs using a green methodology. The obtained β-CDs showed different degree of substitution (DS) between 0.85 and 2.03. These organic macromolecular materials were soluble in common organic volatile solvents, and their structures were investigated by NMR, FT-IR and MALDI-TOF spectroscopies. Thermal analysis showed a correlation between the thermal properties of these derivatives and the benzylation degree. The surface properties of the thin films based on the benzylated β-CDs were characterized by contact angle measurements and atomic force microscopy (AFM). These organic materials were investigated as sensitive layers, deposited on quartz crystal microbalance (QCM) gravimetric transducer, for humidity sensor at room temperature. The results showed that the performances of the prepared sensors are greatly influenced by the benzylation degree of β-CD. The partially modified β-CD (DS=1) shows linear response with best sensitivity, good reproducibility, low hysteresis, fast response time (15s) and recovery time (17s) at higher relative humidity levels (RH) between 11% and 98% in room temperature.

Keywords : β-cyclodextrin, green synthesis, humidity sensor, quartz crystal microbalance
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