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Cellulose nanocrystals: Potential nanofiller for food packaging and catalytic applications

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Cellulose Nanocrystals (CNCs) is a biodegradable, non-toxic, environmentally friendly nanoparticle with immense potential for application in fields such as biomedical engineering, food packaging, sensors, electronic devices etc. In our lab, CNCs using different polymorphs of cellulose were fabricated from raw bamboo pulp through alkali treatment followed by acid hydrolysis. The effect of CNC polymorphs, namely CNC I, CNC II and CNC I→II (CNC II from cellulose I), on its morphology, crystal structure, degree of hydrogen bonding and thermal stability were studied. These polymorphs were dispersed in poly-lactic acid (PLA) films using solution casting approach and their effect on the structural, thermal, mechanical and barrier properties of the PLA was investigated. Incorporation of CNC II and CNC I→II significantly improved the Young's modulus (by~72%). Therefore, the current study provides an insight towards selection of appropriate polymorphs for fabrication of CNC reinforced high performance PLA based bio-nanocomposites. Moreover, we have used the hydroxyl functional groups on CNCs as an anchor point for the simultaneous reduction and stabilization of zero valent nano-particles (ZVI). The CNCs supported ZVI had narrow size distribution along with improved dispersion stability in water. Moreover, this biocatalyst performed well in the degradation of methylene blue and hydrogenation of 4-nitrophenol to 4-aminophenol. Further, we have observed autonomous motion of CNCs supported ZVI in the presence of peroxide fuel, whose locomotion can be externally controlled under both magnetic field and pH gradient. Interestingly, both the fields led to remotely control directionality and speed of the biocatalyst making it a potential candidate for next generation nano-machine for sensors, imaging and drug delivery applications.

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