Functional nanostructured cellulose as potential carrier system for bioactive compounds

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Recent events related to global warming and the dramatic increase in global population have highlighted the urgent need for a sustainable economic model. In this context, biomass has emerged as a vital source of biopolymers. Nanocellulose (NC) has gained attention as a promising material for diverse applications, including crop protection. Its unique physicochemical properties, such as high specific surface area, biocompatibility, and biodegradability, make NC an ideal carrier for the controlled release of agrochemicals. Enhancing the loading of bioactive compounds onto NC often requires chemical modifications to introduce functional groups onto its surface. The primary challenge lies in developing efficient and versatile "green" protocols for these modifications.

In this study, we developed a sustainable synthetic method for incorporating epoxide groups onto nanocrystalline cellulose (NCC). Epoxide groups can be selectively and efficiently post-modified with a wide range of nucleophiles, offering significant versatility. However, the known reported method involves the use of the toxic chemical epichlorohydrin. We replaced this hazardous substance with the safer chemical glycidol. The reaction was performed under homogeneous conditions using a binary mixture of ionic liquids (ILs), 1-ethyl-3-methylimidazolium acetate as the solvent and a sulfonated-imidazolium derivative as the reaction catalyst. The key intermediate was then treated with ammonia under basic conditions aiming to introduce amine groups onto cellulose surface.

The functionalized celluloses produced by both traditional and our optimized method were then compared for their ability to load bioactive compounds, specifically gallic acid. Our innovative procedure yielded a nanocellulosic derivative capable of carrying a higher amount of the bioactive compound. The loaded NC was then co-formulated with chitosan and high amylose starch, then spray-dried to obtain the final formulation as powder. Notably, this nanostructured formulation proved to be an effective and sustainable weapon for the treatment of antifungal diseases involving *Fusarium* crop infections.