Synthesis, Optimization and Characterization of Carboxymethyl Cellulose from Hybridized Agricultural Wastes

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Abstract:
Carboxymethylcellulose (CMC) exhibits extensive commercial relevance across various sectors including oil and gas, cosmetics, food, and pharmaceuticals; however, the prevailing industrial methodology for its synthesis from lignocellulosic biomass demonstrates low sustainability and efficiency. The synthesis of CMC from cellulose generated from agricultural waste materials-more precisely, from a combination of sugarcane bagasse and corncob is reported in this study along with the statistical optimization related to this process. The combined application of a mild alkaliperoxide treatment proved effective for the isolation of cellulose characterized by moderate crystallinity, which was subsequently modified into CMC via the Williamson-ether synthesis. A series of carboxymethylation experiments, determined by Response surface methodology equipped with Box-Behnken design, were conducted to evaluate the independent variables including NaOH concentration, reaction time, the dosage of the etherifying agent, and the categorical factor as solvent for synthesis (ethyl acetate and diethyl ether). Utilizing FTIR, distinctive absorption patterns of CMC were identified, revealing fingerprint bands associated with the absorption and dispersion phenomena of carboxymethyl groups, signifying effective carboxymethylation. XRD measurements indicated that the mild treatment yielded CMC with a considerable proportion of amorphous and type II celluloses. SEM images elucidated the morphological characteristics of the prepared CMC, showcasing reduced surface roughness. The TGA/DTA data pertaining to the CMC illustrates its thermal stability. In contrast to previous research, the results of the analysis of variance derived from the response surface methodology data demonstrated high precision (p-value <0.0001; $R2=0.9666$; $SD<0.03$) and accuracy (characterized by low regression residuals), confirming the extracted waste celluloses' potential for CMC production under mild conditions to produce this high-value biopolymer within the context of industrial chemistry. Hence, the optimized process is characterized by increased sustainability, decreased cost, and higher efficiency.

Keywords:
cellulose, Carboxymethyl cellulose, optimization, characterization, crystallinity.