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PhD Thesis Defense

Entitled
VALORIZATION OF DATE PALM WASTE FOR THE ISOLATION, CHARACTERIZATION, AND SURFACE CHEMISTRY MODIFICATION OF NANOCELLULOSE
By
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Abstract

There are an estimated 42 million date palms in the United Arab Emirates and thousands of tons of date palm waste are produced annually. Date palm waste is a lignocellulosic material and can be used to extract cellulose, which is the most abundant and renewable biopolymer on earth. This dissertation focused on the thorough characterization and kinetic analysis of various date palm wastes to evaluate the percentage of α−cellulose by weight, lignocellulosic nature, and thermal stability, followed by the extraction and characterization of cellulose and nanocellulose (NC). NC is an emerging candidate to produce biodegradable and low-cost composites, bioplastics, insulation materials, food packaging films, etc. The production of NC by conventional hydrolysis processes using sulfuric acid (H_2SO_4) and hydrochloric acid (HCl) is subject to certain limitations that hinder its production on a commercial scale. Ionic liquids (ILs) as green solvents can produce NC from lignocellulosic waste with good physiochemical and thermal properties. This research focused on the extraction and characterization of NC using mineral acids (H_2SO_4 and HCl) and three different ILs (1-ethyl-3-methylimidazolium chloride, 1-butyl-3-methylimidazolium hydrogen sulfate, and 1-butyl-3-methylimidazolium chloride). Investigating the critical aspect of NC yield and particle size, both of which are the most important parameters for determining hydrolysis efficiency. This research thesis presents a novel process in which the hydrolysis of cellulose using mineral acid and ILs is supported by transition metal complexes. Transition metal complex such as copper nitrate in combination with pyridine as a ligand improved the yield by 10−25%, reduced particle size of nanocellulose (≈100 nm), improved crystallinity index (C_{rl}=60−80%), increased thermal stability (T_{onet} ≥250 °C), and activation energy (E_a ≥150 kJ/mol) when used in an amount of 0.5−1.5 wt%. Energy Dispersive X−ray Spectroscopy (EDX) confirmed the purity of the NC with no residual copper. Finally, the hydrophilic nature of NC was modified by a silanization process to make it redisperse, demonstrating its potential application in the production of biodegradable composites. NC extracted using mineral acids and ILs hydrolysis was characterized using advanced techniques, such as transmission electron microscopy (TEM), scanning electron microscopy (SEM), X-ray diffraction (XRD), thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), Fourier transform infrared spectroscopy (FTIR), zeta potential analysis, dynamic light scattering (DLS), and (E_a) analysis. The dissemination of these research results will have a profound impact on the NC production industry, leading to improved yields and the production of nano-sized fibers using green solvents for cellulose hydrolysis, removing the significant limitations associated with mineral acids. The project also helps to highlight the use of lignocellulosic waste and reduce the cost of expensive waste management systems and landfill requirements in the United Arab Emirates and the Gulf region.