6th edition of the International Conference on Materials & Environmental Science, ICMES-2023
June 7-11, 2023, Saïdia – Morocco

Guar-based composites as alternatives for petroleum-based materials

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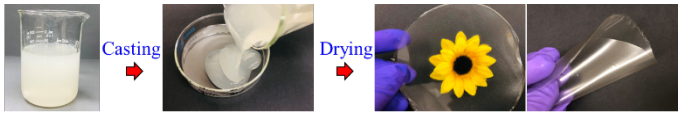
Abstract

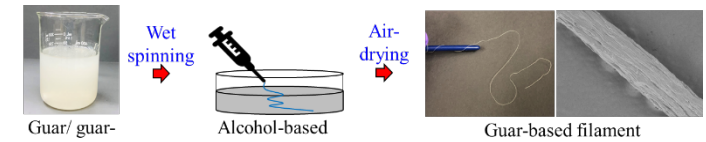
Given the convenience and broad spectrum of applications, plastics have become an essential part of our lives. However, the unintended environmental and health consequences associated with the excessive use of synthetic plastics in our daily lives have become a global problem. Bioplastics made from non-food agroforestry materials are considered most promising and sustainable substitutes for non-renewable petrochemical materials. However, the conversion of agroforestry biomass into bioplastics requires purification and fractionation of the feedstock, followed by dissolution using harsh chemicals. Guar gum (GG) is a galactomannan extracted from guar or cluster bean (*Cyamopsis tetragonolobus L.*). It is emerging as one of the most versatile and low-cost water-soluble biopolymers with unique and fascinating properties. It is a naturally derived thickener, binder, and stabilizer that has uses as an additive to pharmaceuticals, food, cosmetics, and several consumer products. It is also used in huge quantities for hydraulic fracking.

In this study, films, filaments, and aerogels are prepared from guar and guar-cellulose aqueous solutions by cast-drying, wet spinning into an alcohol-based coagulation bath, and freezing followed by freeze-drying, respectively. Glycerol is used to impart plasticity, and borax is used as a crosslinker to improve water stability. Produced flexible and transparent guar-based films exhibited a smooth surface texture, an elongation of about 80% depending on the plasticizer content, and a tensile strength of about 70 MPa depending on the type and quantity of cellulose. Guar-cellulose filaments show a uniform diameter of approximately 0.12 mm, excellent flexibility, elongation up to 140%, and tensile strength up to 17 MPa. The resulting guar-based porous materials show highly porous structures (porosity of ~ 99%) and resemble to starch-based and polystyrene-based "packaging peanuts." After use, these bioproducts can be dissolved in water and reshaped or decomposed as needed.

Guar-based films



Guar-based filaments



Guar-based aerogels

Biography

Dr. Noureddine Abidi is Professor of Biopolymers and Bioproducts and Director of the Fiber and Biopolymer Research Institute at Texas Tech University. His focus is on the chemistry of biopolymers, particularly cellulose, and their transformation to advanced materials. He holds a "Habilitation à Diriger les Recherches" from the University of Haute Alsace in France and a Ph.D. from the University of Montpellier II in France. Dr. Abidi has generated 147 refereed journal publications and book chapters, 3 books, more than 182 presentations, 9 patents/provisional patents. Abidi has served as PI or co-PI on funded research grants totaling more than $17M. He received several awards such as Texas Tech University Chancellor's Council Distinguished Research Award, Texas Tech University Outstanding Research Award, Texas Tech University President's Mid-Career Award, Fulbright US Scholar Award, Texas Tech University Integrated Scholar Award, American Chemical Society Cellulose and Renewable Materials Division Fellow.