ON THE USE OF VARIED NATURAL FIBERS AS SUSTAINABLE SOURCES TO TAILOR HIGHLY EFFICIENT GEOPOLYMER COMPOSITE MATERIALS

Ana C. C. Trindade, University of Illinois at Urbana-Champaign, Department of Materials Science and Engineering
acct20@illinois.edu
Deyvid C. Silva, University of Illinois at Urbana-Champaign, Department of Materials Science and Engineering
Ali Ozer, University of Illinois at Urbana-Champaign, Department of Materials S
Shruti Sood, University of Illinois at Urbana-Champaign, Department of Materials Science and Eng.
Kaushik Sankar, University of Illinois at Urbana-Champaign, Department of Materials Science and Engineering
Prof. Waltraud M. Kriven, University of Illinois at Urbana-Champaign, Department of Materials Science and Engineering

Key Words: geopolymer, natural fibers, sustainability, abaca

Geopolymer materials are ceramic-like structures that present a brittle failure, similar to the ones observed for the cementitious materials. In general, fiber inclusions are used to improve the material ductility and safety under high load demand solicitations. In this regard, synthetic reinforcements are very common due to their standardization in the market. Despite their mechanical efficiency, more renewable and widely available sources can be found in agricultural and nature environments, i.e., the so-called natural fibers. Still, their long-term and large-scale usability remains a challenge to be demystified. Local conditions, treatment type, chemical composition and the hydrophobicity of the natural source are only a few of the factors that may influence the compositional, mechanical and long-term properties of the reinforcement, contributing also to their adequacy to a certain geopolymer matrix. For this reason, this work aims at presenting the more important aspects to be evaluated when considering different natural resources in the context of geopolymer materials. Varied reinforcements have been proposed and experimentally investigated within the research context of the group, such as malva, sisal, curaua, jute, bamboo and abaca. The latter obtained in the U.S., while the others native of the South America and Amazonian regions. Experimentally, they were all incorporated up to 10 wt.% in potassium and sodium-based geopolymer formulations, with metakaolin being the main and only aluminosilicate source. The reinforcements were investigated in long unidirectional arrangements, as well as chopped short widely dispersed fibers. Flexural, direct tensile, splitting tensile, compression, shear, pullout and toughness tests were conducted, showing important differences in the usability of the different natural resources evaluated. A pre-processing step of alkali-treatment was also undertaken, showing irregular efficiency, since different alkali concentrations had to be used depending on the material cellulosic and lúmen content. Additionally, TGA, SEM, and XRD evaluations were used to verify the modifications within the reinforcements following their pre-processing steps. In general, unidirectional alkali-treated curaua and sisal arrangements reached up to 20 MPa in flexural strength, while chopped abaca-based composites were able to reach up to 15 MPa, with no fiber treatment, showing an important effectiveness of this simplified resource and more sustainable fabrication method in the American region.

Figure 1 – Curaua and Abaca fiber arrangements, and the composites flexural strengths.