ABSTRACT

In the present study, jute fabric with plain, twill and matt weave structures were developed and made into a composite with $[0^0]_4$, $[0^0/\pm45^0/0^0]$ and $[0^0/90^0/90^0/0^0]$ lay-up angles using compression moulding technique. It is observed that the matt structure composite shows higher tensile, flexural and impact strength due to availability of more number of yarns per unit area bearing the applied stress. Whereas, matt structure composite shows more water absorption followed by twill and then plain woven composites due to more number of floats in the matt structure that leads to better diffusion. With respect to the lay-up angle, $[0^0]_4$ composite shows increased tensile, flexural and impact strength due to more yarns in the load direction bearing the applied stress. Similarly, $[0^0]_4$ composite shows more water absorption due to less cross over points to hinder the flow of water. Thus, the plain woven composite with $[0^0]_4$ lay-up was optimized for further research to have optimised strength and water absorption.

The plain woven jute fabrics were treated with sodium hydroxide with varying process parameters of time, temperature and concentration. This was optimized using Box and Benkhen experimental design having weight loss and water absorption as dependent variables. From the experimental design the optimum conditions were found to be 4 hrs, 30^0C and 5% NaOH concentration. FTIR results of the treated fabric at optimized condition shows reduced absorbance intensity of the bands 2919.95 cm^{-1} and 1506.42 cm^{-1} corresponds to hemicelluloses and lignin. DSC results also show reduced temperature requirement for degrading hemicelluloses and lignin for treated fabric. These results confirm the reduction in the hemicelluloses and lignin content with the treatment. XRD study shows the shift in crystallinity index

from 66.67 to 67.92 with treatment showing an improvement in crystallinity. AFM analysis confirms the increase in mean roughness of the treated fabric to 67.57 nm from 28.99 nm of untreated that helps in increase adhesion. The rough surface morphology shown in SEM of treated fabric also confirms that mechanical interlocking will be better between fabric and matrix in composite manufacturing. The sodium hydroxide treated jute woven fabric composites shows increased tensile, flexural, impact, pull out and compression strength due to the increase in adhesion between fabric and matrix. It is also observed that the treatment increases the electrical resistivity of the composite due to the removal of hemicelluloses responsible for moisture in the structure that acts as a conducting medium of electricity. The treatment also increases the thermal conductivity of the composite due to increased crystallinity. SEM analysis of the fractured surface of treated composite shows clear surface without any resin deposition indicating increased adhesion between fabric and matrix. It is observed that the sodium hydroxide treated jute fabric composite shows more resistance to the water absorption in distilled, natural and sea water mediums of exposure than the untreated composite due to its increased adhesion that reduces the water diffusion path. It is also observed that the water absorption and thickness swelling are higher in the distilled water than the other mediums due to its impurity free nature that helps in better diffusion. The strength reduction is also less for the treated composites with immersion than the untreated composite.

The developed jute fabrics were also treated with varying time and voltage of oxygen plasma. From that it is observed that 550V and 1 min as an optimum condition because further increase in treatment condition will cause loss in lignin below the required level of 12-15% that in turn leads to reduction in fabric stiffness. FTIR result shows the reduction in hemicelluloses and lignin with plasma treatment. XRD result shows the shift in crystallinity index from 66.67 for untreated to 68.18 for plasma treated jute fabric that confirms the improvement in crystallinity with treatment. From AFM analysis it is confirmed that the mean roughness of the treated fabric increases to 124.14 nm from 28.99 nm for untreated that shows increased surface area for adhesion. SEM study also shows the rough surface morphology of plasma treated jute fabric that assists in better adhesion. The oxygen plasma treated jute fabric composite show increased tensile, flexural, impact, pull out and compression strength due to the increased adhesion of the fabric with matrix. It is also observed that the plasma treatment increases the electrical resistivity and thermal conductivity of the composite. SEM analysis of the fractured surface shows clear surface that also indicates increased adhesion between fabric and matrix with plasma treatment. Similar to the sodium hydroxide treated jute fabric composite, the oxygen plasma treated jute fabric composite also shows more resistance to absorption of distilled, natural and sea water than the untreated composite. It is also observed that the water absorption and thickness swelling are higher in the distilled water than the other mediums of exposure. The strength reduction is also less for the treated composite with immersion than the untreated composite.

The jute composites were analysed for its sound absorption properties by using it as a perforated panel backed by the coir felt. The design variables are optimised using Box and Benkhen design with pore diameter, distance between pores and composite thickness as independent variables and noise reduction coefficient as dependent variable. From the results, it is observed that noise reduction coefficient increases with the increase in composite thickness, decreases with increase in pore diameter and increases initially and then decreases with the increase in distance between pores. This reduction in NRC with increase in diameter and distance between pores is due to reduced number of holes for absorption. The increase in NRC with thickness is mainly due to the availability of longer path for sound waves to break down and die inside the holes. From this, the design variable of the perforation has been optimized as 0.5mm pore diameter with the distance as 8mm and composite thickness of 8mm.