MECHANICAL PERFORMANCE OF NOVEL MULTI-SCALE COMPOSITES DEVELOPED USING MICROCRYSTALLINE CELLULOSE

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ABSTRACT
In this research work, multi-scale glass fibre/epoxy composites were developed using microcrystalline cellulose (MCC). MCC was homogeneously dispersed in epoxy resin using ultrasonication energy and glass fabrics were subsequently impregnated with MCC dispersed resin to fabricate the multi-scale composites. Mechanical and dynamic mechanical behaviours of the developed composites were characterized. It was observed that the flexural strength of glass/epoxy composites increased strongly (up to 76%) through addition of only 1% MCC. Storage modulus of composites also increased significantly (up to 10%) through MCC addition. However, enhancement in mechanical and dynamic mechanical properties reduced at higher MCC loadings as a result of MCC agglomeration.

Keywords: multi-scale composites, micro crystalline cellulose, glass/epoxy composites.

INTRODUCTION
Addition of functional nano and micro materials to the conventional composites to enhance their mechanical, electrical, thermal and other properties is nowadays a common practice. Incorporation of these functional materials to conventional fibre reinforced composites led to the development of multi-scale composites composed of reinforcements from macro, micro and nano scales (Rana, 2016). Among different nanomaterials, carbon nanotubes (CNTs) have been widely researched for this purpose due to their remarkable mechanical, electrical and thermal properties (Rana, 2009). Recently, interest on bio-based nano and micro materials such as nano cellulose is rapidly increasing due to their interesting mechanical and optical properties and also owing to their environmental benefits. These bio-based materials are already being applied in a wide range of industrial applications such as packaging, biomedical, construction, etc. (Parveen, 2017). Looking at the reinforcement potential of cellulose based nano and micro materials, this research work has made the first attempt to incorporate micro crystalline cellulose (MCC) within glass/epoxy composites to enhance their mechanical and dynamic mechanical performances.

For this purpose, MCC was first homogeneously dispersed in epoxy resin using ultrasonication for 1 hour. Then MCC dispersed epoxy resin was used to impregnate the glass fabrics using a vacuum assisted resin transfer moulding technique. Composite samples were fabricated varying MCC loading from 1-3%. Samples were tested for flexural properties using a universal testing machine at a crosshead speed of 2 mm/min and dynamic mechanical analysis was carried out in a HITACHI DMA instrument (DMA7100) at a frequency of 1Hz and over temperature range of 30 - 180°C.
RESULTS AND CONCLUSIONS

The results of flexural tests are shown in Figure 1 and the average flexural strength data has been presented in Table 1.

Table 1 - Flexural test results

<table>
<thead>
<tr>
<th>Samples</th>
<th>Flexural strength [MPa]</th>
<th>% Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass/epoxy</td>
<td>289.8</td>
<td>-</td>
</tr>
<tr>
<td>Glass/epoxy with 1% MCC</td>
<td>510.2</td>
<td>76.0</td>
</tr>
<tr>
<td>Glass/epoxy with 1.5% MCC</td>
<td>480.2</td>
<td>65.7</td>
</tr>
<tr>
<td>Glass/epoxy with 3% MCC</td>
<td>435.1</td>
<td>50.1</td>
</tr>
</tbody>
</table>

Fig. 1 - Flexural load-elongation curves

It can be observed that flexural strength of glass/epoxy composites increased strongly (up to 76%) through addition of 1% MCC, above which, however, a decrease in flexural property improvement was noticed, mainly due to MCC agglomeration. The storage modulus of glass/epoxy composites also improved up to 10% using 1.5% MCC.

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REFERENCES

