

# Development and validation of a guarded hot plate apparatus for measuring biocomposite insulation properties

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A guarded hot plate apparatus was developed and calibrated using thermal insulation material to assess the thermal conductivity of biocomposites in the range from 70°C to 350°C. Precision testing resulted in a combined measurement uncertainty of  $\pm 2.59\%$ . The apparatus evaluated biocomposites reinforced with 4%, 8%, and 12% bamboo, banana, and coir fibres in unsaturated polyester resin. Among the composites, 12% bamboo fibres exhibited the lowest thermal conductivity (0.048 W/mK), while 4% banana fibres showed the highest (0.0744 W/mK). Coir composites demonstrated moderate conductivity. A linear decrease in thermal conductivity, diffusivity, and density, along with an increase in specific heat, was observed with increasing fibre content, confirming the potential of these biocomposites for insulation applications.

**Keywords:** Biocomposites, guarded hot plate, natural fibres, measurement uncertainty, thermal conductivity, thermal diffusivity.

However, biocomposites mechanical properties have been studied more than their thermal (insulating) properties. Understanding and managing thermal conductivities is essential for environmentally and economically viable insulating material development. The performance of insulating materials depends on their thermal conductivity.

The guarded hot plate (GHP) method is the most accurate way to measure thermal conductivity when dealing with materials that have low conductivity ( $<0.1$  w/mk)<sup>11-14</sup>. It is widely used for insulating materials and is recognised by both the American Society for Testing and Materials (ASTM) and the International Organisation for Standardisation (ISO-8302) as the most precise measurement method<sup>15,16</sup>. Though the steady-state method is also used, it requires an expensive experimental setup and takes time. There are two methods for measuring the insulating properties of biocomposites. The GHP method has a range of -193°C to 527°C and a 2% uncertainty<sup>17</sup>. The heat flow meter can be used for normal (100°C–200°C) (ref. 18), axial (-183°C–1027°C), and radial (25°C–2327°C) heat flow<sup>19</sup> at various temperatures with a 3–10% uncertainty. Despite this, the GHP method remains the primary and most accurate method for measuring thermal conductivity.