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The effect of surface texture and carbonaceous material composition on the dielectric properties measurement of coconut shell-polymer (CSP) composites

Abstract

The dielectric properties of a microwave absorbing material represent the ability of the material to absorb microwave signals and dissipated those signals as heat. Carbonaceous materials are preferable to be used as microwave absorbing material due to their excellent dielectric properties. In this paper, coconut shell in powder form was used as the carbonaceous material and the composite samples were prepared in epoxy resin matrix. Five different ratios of coconut shell: Epoxy resin (30:70, 40:60, 50:50, 60:40, 70:30) were prepared in order to investigate the effect of carbonaceous material composition on the dielectric properties measurement. Composites with smooth and rough surface textures were fabricated in order to investigate the effect of surface texture on the dielectric properties measurement. Carbon, hydrogen, nitrogen and sulphur (CHNS) elemental analysis was performed to determine the carbon composition in coconut shell powder. It was evaluated that the coconut shell powder possesses 48.37% of carbon composition. The structural characteristic of the coconut shell powder particles and surface texture were examined using scanning electron microscope (SEM). Presence of irregular shape particles with macropores range (1 µm) porosities was detected in the coconut shell powder. Presence of uneven surface with air gap of approximately 60 µm in diameter was detected on composite with rough surface. Experimental measurement on the dielectric properties of coconut shell-polymer (CSP) composites was performed by using open-ended coaxial probe method over microwave frequency range of 1-8 GHz. It was found that the surface texture of the composites influenced the measurement accuracy of the dielectric properties. From the experimental results, composites with smooth surface texture exhibit statistically significant accuracy of dielectric properties measurement (real part) with error bars that are less than 5% ($\varepsilon r' = \varepsilon r' \pm 0.05|\varepsilon r^*|$), compared to rough composites surface where the error bars exceeded 5 %. The measured dielectric properties for composites were directly proportional to the composition of coconut shell powder. The optimum range of dielectric properties at $\varepsilon r'$ (3.599-3.966), $\varepsilon r''$ (0.381-0.572) and tan δ (0.101-0.152) was measured for composite with 70 wt% coconut shell powder composition. The

electrical conductivity of the composites increased accordingly as the composition of coconut shell powder increases over frequency of 1-8 GHz. The prepared coconut shell-polymer composites can be utilized for electromagnetic suppression (EMI) application.

Keywords; Carbonaceous; Dielectric properties; Surface texture