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RESEARCH PAPER

Materials' characterization and properties of multiwalled carbon nanotubes from industrial waste as electromagnetic wave absorber

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Abstract The development of high-frequency devices has attracted more research interest in electromagnetic wave–absorbing materials having lightweight, low filler content, thin thickness, minimum reflection loss and broad absorption bandwidth. Nevertheless, none of the materials uses steel waste (mill scale) as a potential low-cost catalyst to synthesize carbon nanotubes (CNT) as an electromagnetic (EM) wave absorber. Hence, multi-walled carbon nanotubes loaded in epoxy resin with an increasing polymer composite thickness of 1 mm, 2 mm, and 3 mm were introduced in this study. With varying milling times of mill scale (4 h, 20 h and 40 h) as catalyst, as-synthesized carbon nanotubes were produced using the chemical vapour deposition (CVD) method. Two main phases (carbon and iron carbide) were obtained from the synthesized carbon nanotubes. The samples' morphology was mostly straight like, spiral, twisted carbon and spring pasta-like structures. The two-dimensional (2D) network structure of as-synthesized CNT loaded into epoxy resin, extends the transmission route of EM wave being absorbed. Moreover, the ratio of I_D/I_G is consistent at around 1.0 attributed to defective structure or a lower graphitization degree. In addition, higher electrical resistivity in the sample indicates wider separation between CNTs allowing for better EM wave absorption. The as-synthesized carbon nanotubes that are utilized as filler with lightweight properties, improved the reflection loss approach to − 25 dB (10.5 GHz) for growth CNT catalyzed by mill scale milled for 20 h loaded into polymer matrix (GM20h/P) at thickness of 3 mm. As the thickness of the polymer composites increased from 1 to 3 mm, all composite samples reflected a loss peak closer to a lower frequency range. The results demonstrated that the EM wave absorption ability was improved to 99.9% by using nanometer size mill scale waste as a catalyst to grow carbon nanotubes and further used as an EM wave absorber.

Keywords Mill scale · Nanometer · Filler · Carbon nanotubes · Absorbing materials · Nanostructured catalysts

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