Preparation and characterization of semi-flexible substrate from natural fiber/ nickel oxide/polycaprolactone composite for microstrip patch antenna circuitries for microwave applications

ABSTRACT

The study intended to utilizing waste organic fiber for low-cost semi-flexible substrate fabrication to develop microstrip patch antennas for low band communication applications. All the semi-flexible substrates (12.2 wt. % OPEFF/87.8 wt. % PCL, 12.2 wt. % NiO/87.8 wt. % PCL, and 25 wt. % OPEFF/25 wt. % NiO/50 wt. % PCL) were fabricated by oil palm empty fruit fiber (OPEFF) mixed with nickel oxide (NiO) nanoparticles reinforced with polycaprolactone (PCL) as a matrix using a Thermo Haake blending machine. The morphology and crystalized structure of the substrates were tested using Fourier transform infrared (FTIR) spectrometry, X-ray diffraction (X-RD) technique, and scanning electron microscopy (SEM), respectively. The thermal stability behavior of the substrates was analyzed using thermogravimetric analysis (TGA) and differential thermogravimetric (DTG) thermogram. The dielectric properties were characterized by an open-ended coaxial probe (OEC) connected with Agilent N5230A PNA-L Network Analyzer included the 85070E2 dielectric software at frequency range of 8 to 12 GHz. The experimental results showed that NiO/OPEFF/PCL composites exhibit controllable permittivity dielectric constant ε′r(f) between 1.89 and 4.2 (Farad/meter, (F/m)), with loss factor ε"r(f) between 0.08 and 0.62 F/m, and loss tangent (tan δ) between 0.05 and 0.18. Return losses measurement of the three patch antennas OPEFF/PCL, NiO/PCL, and OPEFF/NiO/PCL are −11.93, −14.2 and −16.3 dB respectively. Finally, the commercial software package, Computer Simulation Technology Microwave Studio (CSTMWS), was used to investigate the antenna performance by simulate S-parameters based on the measured dielectric parameters. A negligible difference is found between the measured and simulated results. Finally, the results obtained encourage the possibility of using natural fibers and nickel oxide in preparation of the substrates utilize at microwave applications.

Keyword: Nickel oxide; Patch antenna; Polycaprolactone; CSTMWS; S-parameters