ABSTRACT

The present study was aimed to prepare preheated nano-graphene oxide added Karanja oil (HGKO) with optimal nano dispersion parameters and to compare its fuel properties with preheated Karanja oil (HKO), Karanja oil (KO) and diesel. The combustion, performance, and emission characteristics of a 4-stroke, single cylinder, water cooled, direct injection 10-kW diesel engine were studied with the prepared test fuels. Initially, samples were prepared with the selected dosage of graphene oxide (GO) (30-90 ppm), Sodium Dodecyl Sulfate (SDS) with GO:SDS ratio of 1:1 to 1:5 and were subjected to ultrasonication stirring for 30-45 minutes. The stability of nano dispersed fuel was decided based on zeta potential value. The optimal dispersion parameters were obtained using a well-trained radial basis function (RBF) neural network integrated with the particle swarm optimization (PSO) technique to prepare HGKO with higher stability and to save surfactants and electricity. The predicted optimal nano dispersion parameters were 58.3 ppm GO, 180.4 ppm SDS and 38 min ultrasonication time. The variation in actual and predicted zeta potential was found to be -3.26% measured after 6 h from the time fuel was prepared, which confirmed reliability and adaptability of the developed model. The suitable temperature for heating KO and GKO was decided based on the temperature-viscosity profile of these two fuels and it was taken as 105 °C as viscosity of these two fuels at this temperature was reduced to the limit prescribed by the ASTM standard. The fuel properties of prepared test fuels were measured by following the latest ASTM standards and found to be closer to the limits prescribed by American, European and Indian Standards for biodiesel and biodiesel blends.

The average ignition delay for KO based fuels was found to be lesser (up to 3.36%) as compared to diesel due to availability of extra oxygen in KO based fuels. KO based fuels showed lesser peak CGP (up to 3.56%) and HRR (up to 25.16%) as compared to diesel due to their lesser calorific value and ignition delay (ID) period. HKO showed 0.96 and 5.97% higher CGP and HRR, respectively as compared to KO due to improved vaporization and mixing characteristics at elevated temperature for HKO. Addition of GO nanoparticles in HKO accelerated the combustion process and improved the fuel reactivity and reduced ID thereby lesser fuel got accumulated in premixed combustion phase, which resulted in lesser CGP (up to 4.82%) and HRR (up to 25.52%) as compared to HKO. Preheated GKO showed comparable performance with diesel and showed higher BTE (upto11.81%), lesser BSFC (up to 17.72%) and EGT (up to 4.11%) as compared to KO and HKO. On an average, HGKO showed lesser HC emissions up to 44% as compared to KO and HKO. Average CO and NO_X emissions for HGKO were 11.28 to 40.91% and 2.73 to 10.76% lesser, respectively as compared to KO, HKO and diesel due to enhanced fuel reactivity, mixing characteristics, and lower residence time. Hence, HGKO fuel can be recommended for use in diesel engine as a substitute for diesel to achieve sustainable energy goals.

Keywords: Graphene oxide added Karanja oil; RBF-PSO; Nano-fluid dispersion; Fuel properties; Combustion; Performance; Emission