Cellulose Nanocrystal-Aluminium Oxide (CNC-Al2O3) for Tribology Application in Internal Combustion Engine: Stability, Thermophysical and Tribological Behavior

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ABSTRACT

The experimental study investigates the stability, thermophysical, and tribological characteristics of cellulose nanocrystal (CNC), aluminum oxide (Al2O3), and hybrid CNC-Al2O3 nanolubricants as additives in SAE 40 engine oil. Stability assessments were conducted through sedimentation observation, UV-visible spectroscopy, and zeta potential analysis at various concentrations (0.01% to 0.05%) and temperatures (30°C to 90°C). The hybrid CNC-Al2O3 nanolubricants demonstrated excellent dispersion stability with zeta potential values exceeding 150 mV at optimal concentrations. Thermophysical property analysis revealed that dynamic viscosity increased significantly, with the hybrid system showing a 56% enhancement at 0.03% concentration and 30°C. The coefficient of friction (COF) results showed remarkable improvement, with 0.01% CNC-Al2O3 concentration achieving a 78.6% reduction compared to base oil. The specific wear rate demonstrated progressive improvement with increasing concentration, reaching optimal values of 0.016 mm³/Nm at 0.05% concentration. These findings indicate that CNC-Al2O3 hybrid nanolubricants at optimal concentrations provide enhanced tribological performance and improved thermophysical properties, making them promising candidates for internal combustion engine applications.

**Keywords:** Hybrid nanolubricant; cellulose nanocrystal; aluminum oxide; viscosity; thermal conductivity; tribological behavior; stability analysis; wear rate; coefficient of friction; engine oil