O1 CHEM1

CHARACTERIZATION OF BASE OILS FOR ENGINE LUBRICANTS BY NIR AND FLUORESCENCE SPECTROSCOPIES COUPLED WITH CHEMOMETRICS

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The present study is focused on Engine Lubricant also called Engine Oil or Motor Oil.
Typically, lubricants contain 80% base oil and less than 20% additives that improve the oil performances.
One of the most common classifications for lubricants is by the constituent base oil: mineral, synthetic or vegetable. Mineral oils are derived from crude oil, synthetics are man-made through a synthesizing process, while vegetable base oils, which are derived from plant oils, represent a very small percentage and are used primarily for renewable and environmental interests.
Although, generally, lubricants are based on one type of base oil, mixtures of base oils are also used to meet performance requirements and to improve different properties in the formulations.
The American Petroleum Institute (API) has categorized base oils into five categories. The first three groups are refined from petroleum crude oil. Group IV base oils are full synthetic (polyalphaolefin) oils. Group V includes all other base oils not included in Groups I to IV.
It is possible to distinguish pure base oils by looking at the combination of physical properties such as viscosity index, density, colour, flash point, pour point, aniline point, thermal stability. Nevertheless, identification of a mixture of synthetic and mineral oils represents a big analytical challenge, due to the variable composition of base stock and additives.
A rapid solution to determine the type of base oil in lubricants could help the formulators when developing a new or tailored lubricant, targeting a given performance level. Since spectroscopy techniques are low-cost, green, non-destructive and fast, in order to reach this goal, the capabilities of near infrared (NIR) and Excitation-Emission matrix (EEM) fluorescence spectroscopies coupled with chemometrics have been investigated.
Fifty-three base oil samples and 25 lubricant samples have been analyzed by means of NIR and fluorescence spectroscopy. NIR spectra were acquired with a FT-NIR spectrophotometer (Buchi NIRFlex N-500), in the 4000-10000 cm^{-1} range at 4 cm^{-1} resolution. All the experiments were performed at controlled temperature (35°C). The Excitation–Emission fluorescence measurements were performed at room temperature with a PerkinElmer LS 55 spectrometer. According to the results of a preliminary D-Optimal experimental design, the excitation spectra were recorded between 200 and 500 nm, the emission wavelengths ranged from 300 to 900 nm; the excitation and emission monochromator slits were set to 4.5 and 11.0 nm, respectively, and the scan speed was set at 200 nm/min.

O1 CHEM1

Principal Component Analysis (PCA) was performed as a multivariate display method in order to visualize the data structure, and multivariate classification tools were investigated in order to distinguish among different API base oil groups.
Both NIR and fluorescence results showed a potential for differentiating the different base oil samples and their mixtures according to the API categories. Spectroscopic techniques appeared to be rapid and non-destructive analytical methods for the characterization of base oils into Engine Lubricants and, therefore, might also represent a promising tool for Gasoline Engine Oil analysis.

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