A new way to decode the solvency of base oils

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The aniline point and its importance in the lubricant industry

The aniline point of mineral base oils is a crucial indicator when it comes to formulating lubricants, especially in high-performance or sensitive applications. It essentially reflects the solvency power of a base oil, how well it can dissolve additives or other components in a lubricant formulation. A lower aniline point means higher solvency, which is important for dissolving polar additives (like detergents, dispersants, or antioxidants). This is typical of Group I or naphthenic base stocks and can be beneficial for certain applications that demand high additive loading or where varnish and deposit control is a concern.

On the other hand, Group II and III base stocks often have higher aniline points, indicating lower solvency but better oxidation stability and higher viscosity index – ideal for more modern, thermally stable formulations.

For some industrial applications such as the plasticisation of rubber, the production of greases and metalworking fluids, high solvency is essential. In addition to the technical challenges, the global transition to more highly refined and therefore less soluble products poses major challenges for the industry.

Traditional determination of the aniline point

Knowing the actual aniline point of base oils is crucial for product development and incoming product quality control. The value is given in °C and describes the lowest temperature at which the chemical substance aniline remains in solution under test conditions. The measurement is typically carried out according to the standard test method ASTM D611. Measuring devices for determining the aniline point are offered by various suppliers with different degrees of automation.

In all cases, the fundamental problem comes from the chemical substance aniline itself, which is toxic, can cause physical damage, is suspected of being carcinogenic and is also extremely bad for the environment. All in all, this is a substance that every operator tries to avoid. Depending on the method, one determination takes between 20 and 60 minutes, including sample preparation.

New approach for estimating the aniline point with FTIR infrared spectroscopy

FTIR (Fourier Transform Infrared Spectroscopy) measurements are widely used in the lubricant industry because this method offers a fast, non-destructive, and detailed chemical analysis of lubricants, both fresh and used. The monitoring of

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degradation and contamination is often of interest, and also the determination of the presence and depletion of additives.

FTIR works by passing infrared light through a sample and measuring how different wavelengths are absorbed, creating a spectrum that reveals the sample's molecular composition.

In this context, chemometrics refers to the use of mathematical and statistical methods to extract meaningful chemical information from FTIR spectra for analysing lubricant properties and conditions. This principle has already proven to be applicable for prediction of Total Acid Number (TAN) and Total Base Number (TBN).

In a pilot project, it was possible to show that the aniline point of base oils can be estimated using FTIR with the support of a suitable chemometric model.

Proof of concept with FTIR infrared spectroscopy

As part of the proof of concept, a total of 30 base oil samples in a range of kinematic viscosities at 40°C between 8 mm^2/s and 115 mm^2/s were used. This corresponded to aniline points between 70°C and 105°C. The measurements were performed with ERASPEC OIL, the FTIR Spectral Lubricant Analyzer from eralytics.

In Figure 1 all measured infrared spectra are plotted for comparison. It is obvious that no straightforward approach is applicable, but it is possible to see certain variations, for example in the range between wavenumbers 650 cm^{-1} to 950 cm^{-1}, but also in other sections.

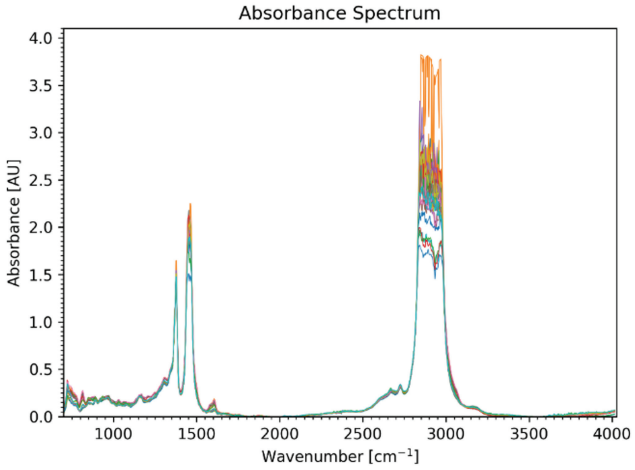

Figure 1: *Transmission spectra of all 30 samples*

For the present case, a chemometric multilinear regression model (MLR) was developed to combine information from different areas. In Figure 2 the cross plot between calculated values and given reference values for the aniline point is shown. The calculated Standard Error of Calibration (SEC) was 1.0°C.

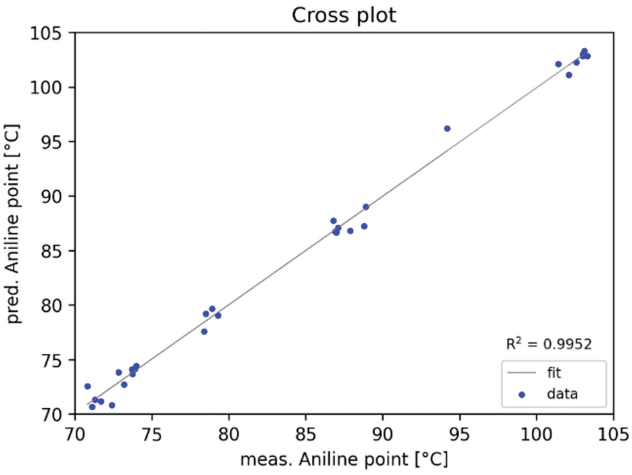

Figure 2: *Cross plot showing measured aniline point versus the predicted value*

This number is compared to the reproducibility of 0.5°C for clear and light-colored samples according to ASTM D611 and gives a very reasonable outcome. It must be taken into account that all samples were used across a wide viscosity range. It can be assumed that the significance can be further improved in further studies. It is also possible to consider the density of the respective sample in the model, as this is usually also determined.

Conclusion

Knowledge of the aniline point of base oils is of great importance in the lubricating oil and process oil industry, as it poses challenges and opens technical opportunities. In contrast to the classic determination via the solubility of the extremely questionable substance aniline, an alternative approach could be demonstrated with FTIR infrared spectroscopy. This measurement takes just a few minutes and also provides deep insights into the composition and condition of the base oils.

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