Development of a Microscale Vapor Pressure Analyzer to Assess the Dangers of Fumes and its Possible Health Effects

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Instrumentation

The K24870 Automatic Microscale Vapor Pressure Analyzer conforms to the specifications of ASTM D5191 and D6378. These methods are successful in fulfilling the market demands, Requiring only small amounts of sample and including automated procedures. The unit is small, making it easier to transport and use in the field or in the laboratory. The methods are effective in simplifying the vapor pressure testing process and will efficiently serve the industry for years to come.

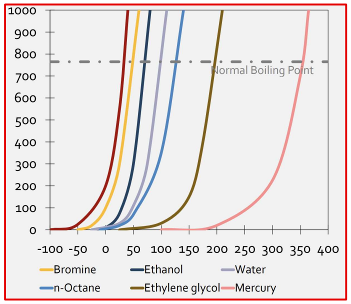
Overview

Vapor pressure is important to measure in our industry, since a failure to account for a sample's vapor pressure can lead to accidents that impact the environment and human health. Volatile petroleum products can contribute to ground-level ozone, which is associated with numerous human health problems. To combat this, some governments regulate the vapor pressure of some petroleum products, such as gasoline, due to air pollution standards. For example, the EPA restricts the Reid vapor pressure of commercial gasolines during the summer to be less than a value of either 7.0, 7.8, or 9.0 psi, depending on the state and county. Therefore, vapor pressure testing is required to guarantee the gasoline meets the regional vapor pressure standard.

In 1999, the triple expansion method for vapor pressure determination was developed and is provided by ASTM D6378. This revolutionary method was developed by Dr. Grabner, and now serves as the new standard of vapor pressure testing in our industry. This method uses a piston to expand the test chamber, for a total of three expansions. At the end of each expansion, the total pressure in the chamber is measured. From the three pressure measurements along with the volume after each expansion, the partial pressure due to dissolved air is calculated. The vapor pressure (VPx) of the sample is then calculated by subtracting the partial pressure of air from the total pressure after the third expansion. ASTM D6378 also provides correlative equations to calculate the RVPE and DVPE.

What is Vapor Pressure?

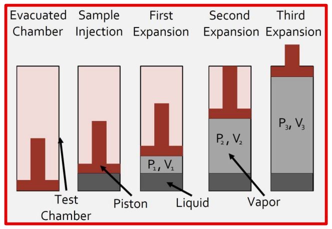
These ASTM methods provide practical procedures to determine the vapor pressure of a sample. In scientific terms, the vapor pressure of a liquid is the pressure exerted by the liquid's vapor when the vapor and liquid are in equilibrium and is an indicator of a substance's volatility. The vapor pressure of a substance depends on the temperature and the composition of the substance, and the graph shown below is an example of how temperature and substance composition will affect the vapor pressure.



Operation of ASTM D6378

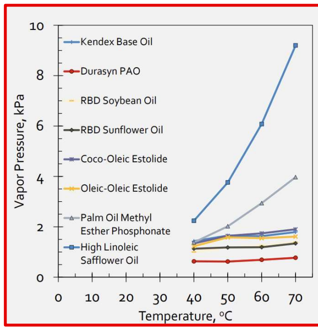
At the end of each expansion, the pressure and volume is measured. These values are used to calculate the sample's vapor pressure with the following equation:

$$VP = P_3 - \frac{(P_1 - P3)(P_2 - P_3)}{\frac{V_3 - V_1}{V_2 - V_1}(P_1 - P_2) - (P_1 - P_3)}$$



Comparative Analysis

Various samples were tested to determine their vapor pressure with the Koehler K24870 unit. The samples were provided by the United States Department of Agriculture. The vapor pressure of each sample was measured as a function of temperature, under the guidelines of ASTM D6378. The results for the vapor pressure testing is shown in the table below in units of kPa.



Sample	40°C	50°C	60°C	70° C
Kendex Base Oil	1.43	1.65	1.63	1.79
Durasyn PAO	0.63	0.62	0.69	0.77
RBD Soybean Oil	1.00	1.17	1.25	1.39
RBD Sunflower Oil	1.13	1.18	1.19	1.34
Coco-Oleic Estolide	1.34	1.64	1.74	1.90
Oleic-Oleic Estolide	1.23	1.58	1.55	1.61
Palm Oil Methyl Esther Phosphonate	1.38	2.02	2.94	3.97
High Linoleic Safflower Oil Methyl Ester Phosphonate	2.24	3.76	6.08	9.20

The data expresses the theoretical relationship between the vapor pressure and temperature. Generally, as the temperature increases, the vapor pressure will increase exponentially. This is clearly shown in the results, especially for the Palm Oil and High Linoleic Safflower Oil Methyl Ester Phosphonate samples. The other samples express only a slight increase in vapor pressure with temperature, so perhaps to obtain a better curve, a higher temperature range should be used. This experiments shows the versatility of this vapor pressure instrument, as it can measure for a wide variety of samples.

Conclusion

The instrument used in this poster, the Koehler K24870, is a cutting-edge unit in our industry. Overall, ASTM D6378 is an innovative method for vapor pressure testing and reduces the need for outdated methods, like ASTM D323. Instrumentation for ASTM D6378 is effective in improving the vapor pressure testing process by producing repeatable results with automatic procedures