Application Note:

Viscosity Measurement of Volatile Compounds

Application

This application note addresses the ability of VROC™ technology to measure viscosities of highly volatile compounds or solvents. Accurate viscosity measurement of volatile compounds is challenging with conventional rheometers — the sample-air interface is always a source of solvent evaporation.

Solvent evaporation changes the effective sample volume and causes temperature variation, which influences viscosity measurements. To minimize evaporation while testing with rheometers, researchers have created various fixtures, which are often cumbersome or require significant time to stabilize[1].

For accuracy, repeatability, ease and efficiency, the VROC™ is recommended. With this precise measurement tool, *test liquid flows through a confined channel, eliminating the problem of evaporation during test and evaluation.*

For this application note, viscosity of various volatile solvents were measured and compared to reference values published in CRC Handbook of Chemistry and Physics[2].

Sample Preparation and Test

HPLC grade 200 proof ethanol, Isopropyl alcohol (IPA), and heptane were acquired from Sigma-Aldrich. Industry-grade methyl-ethyl-ketone (MEK) and acetone were obtained from a local hardware store.

All measurements were performed at 25°C ±0.2°C.

[1] J. Sato and V. Breedveld, "Evaporation Blocker for Cone-Plate Rheometer of Volatile Samples," Appl. Rheol., 15 (2005) 390-397.

[2] CRC Handbook of Chemistry and Physics, 74th ed., CRC Press, Boca Raton.

Measurement Procedure

1) Load the sample into a syringe.
2) Mount the syringe to the pump.

   The syringe and A-05 VROC chip were connected through a switching valve. A-05 is a chip with a 50 um flow channel depth, designed for a sensitive and accurate measurement of the low viscosity range (0.2 ~ 100 cP).
3) Turn on the water bath to control the temperature jacket for the syringe and the chip at 25 °C.
4) Measure viscosity.
5) Repeat the procedure for the next sample.

Results

The table below compares the measured viscosities of various solvents with the reference values published in the CRC Handbook.

Solvents	CRC Handbook	VROC™
IPA	2.038	2.073
MEK*	0.405	0.373
Heptane	0.387	0.385
Acetone*	0.306	0.303
Distilled Water	0.89	0.907
Ethanol	1.074	1.08

* : solvents from local hardware store

The standard deviation was calculated with three or more measurements. The results — deviation was less than 0.005 cP, demonstrating excellent repeatability. As shown in the table above, the VROC data are in close agreement with the reference values of the CRC handbook; the differences are within +/- 0.94% of the reference values. The exceptions are with the industrial grade solvent of MEK, which was purchased from local hardware stores.

Summary

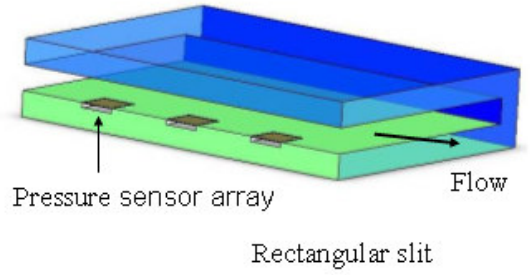
- VROC™ is demonstrated as an effective viscosity measurement tool for volatile compounds
- High accuracy and high resolution
- Water can be too volatile for accurate viscosity measurement using conventional rheometer

Principle of Viscosity Measurement with VROC™

The viscometer-on-a-chip measures viscosity from the pressure drop as the test liquid flows through a rectangular slit. This scientific application is well known (K. Walters, Rheometry[3]).

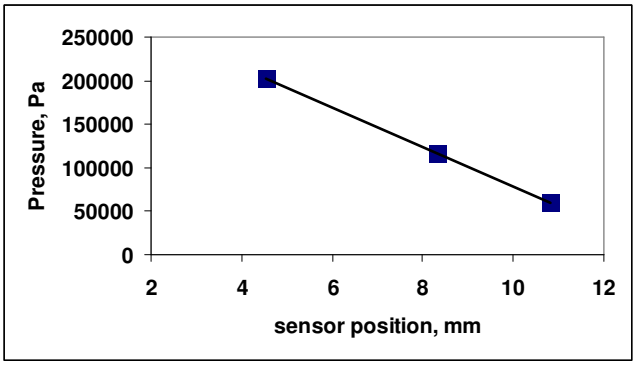
Physical Structure

The VROC chip consists of a rectangular slit that is formed with glass and a monolithic Si pressure sensor array. The width of the rectangular slit is far greater than the depth of the slit — the edges of the slit are a negligible contribution to the pressure drop.



Usage

When the test sample is pumped to flow through the slit channel, the monolithic pressure sensor array measure pressure at separate locations. As previously described, the flow disturbance is negligible.



Data was obtained for Newtonian Glycerol at 1,220 s^{-1} using a type C sensor.

Packaged VROC™ Chip

If you have questions or need more information, please contact us.

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[3] K. Walters, Rheometry, Chapman and Hall, London, 1975