RHEOLOGICAL PROPERTIES OF COAL-TAR PITCH BINDERS

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Summary

It is found that the viscosity-temperature relation of various pitches can be approximated from the softening point. At the respective softening point, the viscosity is the same to a first order of approximation, for all the pitches studied. The viscosity-temperature relation obeys Duhring's rule which can be advantageously used in intrapolating and extrapolating viscosity data to temperatures of practical interest. The conclusions given for "pure" pitches are also valid for binary mixtures of miscible pitches.

Experimental

The softening points of six coal-tar pitches and their mixtures were determined by the ASTM cube-in-air method.[1] The viscosity was measured using a Brookfield, Model RVT, Synchro-Lectric Viscometer.[2]

Theory and Results

Plots of the logarithm of the measured viscosities *versus* temperature are linear and nearly parallel for the family of pitches studied. Each of these straight lines is represented by the relation

$$\log (\log \eta) = R - b \log T \qquad (1)$$

where η is the viscosity, R is a material constant and b is a universal constant. The values of R and b were calculated and are summarized in Table I. The slope, b, is nearly the same for all the pitches. In consequence, the family of parallel lines can be made to coincide by a translation parallel to the temperature axis. Figure 1 is such a translation and shows a plot of $\log \eta$ *versus* reduced temperature (T/T_s) where T_s is the softening point of the pitch and T is the temperature of a particular viscosity. The straight line in Figure 1 is described by the relation

$$\log (\log \eta) = \log \eta_o - b' \log (T/T_s) \qquad (2)$$

Since b and b' were found to be the same, equation (2) takes the form

$$\log (\log \eta) = \log \eta_o - b \log (T/T_s) \qquad (3)$$

TABLE I

Values of R, b, η_o and b' for Various Coal-Tar Pitches

Pitch	Softening Point, T_s °C	Softening Point, T_s °K	R	b	η_o	b'	%BI	%QI	%TI
1	96.8	369.8	2.7×10^{23}	8.9	3.7	8.9	15.0	5.6	17.0
2	102.9	375.9	7.0×10^{22}	8.7	4.3	8.7	30.1	11.0	29.7
3	116.4	389.4	5.2×10^{22}	8.5	4.2	8.5	34.5	13.3	32.0
4	132.4	405.4	3.9×10^{22}	8.4	4.1	8.4	40.1	15.6	26.5
5	145.9	418.9	5.3×10^{21}	8.1	4.1	8.2	35.9	13.7	36.5
6	170.3	443.3	1.3×10^{21}	7.8	4.4	7.7	45.1	19.0	42.5

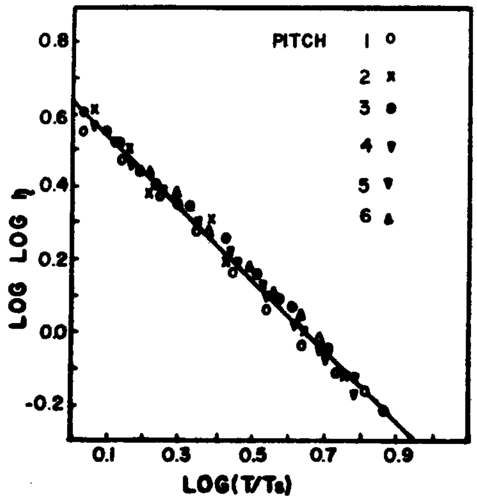

Figure 1. Log Log Viscosity Versus Log (T/T_s) for Various Coal-Tar Pitches

where η_o and b are considered to be the same for the family of pitches. Thus, equation (3) suggests that:

(a) The viscosity is the same for all the pitches at the respective softening points $(T=T_s)$, i.e., $\log\,(\log \eta)_{(T=T_s)} = \log\ \eta_o$.

(b) The viscosity-temperature relationship can be described by a single characteristic parameter - the softening point, T_s.

(c) The viscosity-temperature relationship obeys Duhring's rule which is useful in intrapolating the viscosity data to temperatures of practical interest such as the temperatures of mixing and forming of carbon artifacts.

Using the technique employed for pure pitches, values of η_o and b were calculated for pitch mixtures. The values of R and b of mixtures suggest that all the generalized relations derived for individual pitches are applicable to mixtures. This confirms the concept that the softening point, T_s, can be used to describe the viscosity-temperature relation of any pitch.

References

1. ASTM Method, D-2319-66, Vol. 11 (1969).
2. A. Roeger, M.S. Thesis, The Pennsylvania State University (1969).