Shear Viscosity, Rheology

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Paint technologists and also applicators often need to know about a coating’s shear viscosity or rheology at low, medium, or high shear rates. What in fact they are asking then is to know how that particular coating responds, when a certain amount of shear (force) is applied to it, normally during some application method. This knowledge will allow a formulator or applicator to predict to a certain degree the application properties and the final film performance the applied coating will have.

Practical Usage

a) Low shear viscosity is normally measured at shear rates of 0.1- to 400 s⁻¹ and governs things like:
   - Flow (at shear rates 0.1-10 s⁻¹). A low value indicates good flow, a high value poor flow.
   - Sag (drip, run) resistance (at shear rates 0.1-10 s⁻¹). A low value indicates paints that are more likely to sag.
   - Settling resistance (at shear rates 1-100 s⁻¹). Low values indicate more chance of settlement.
   - The in-can viscosity appearance (measured at shear rates 100-400 s⁻¹) determines the appearance of the paint in the can. For a lot of markets, the higher the value the better.
b) Medium shear is normally measured at shear rates of 400-1200 s⁻¹ and is mainly associated with roller application—a low value means overspreading will occur, a high value normally means the paint will be restrictive and give a higher film build and opacity. Too high a value can imply that the roller slips and slides which can give appearance and opacity problems.
c) High shear is normally measured at shear rates of 8,000-12,000 s⁻¹ and is mainly associated with brush application. Again, a low value means overspreading, poor opacity and film build, a high value indicates restrictive application and good film build and opacity, a very high value can lead to poor sag resistance, appearance and flow.
d) Ultra high shear is normally measured at shear rates of 20,000-40,000 s⁻¹ and is almost exclusively associated with spray application (ease of atomisation), but also to a lesser degree shear stability of the coating and resin, which is very important for latices and in some high tech applications.

Obviously, a coating under goes different shear rates at different points in its manufacture, storage, application, drying, and cross linking phases. Thus, to measure or consider the viscosity or rheology at only one shear rate is fairly meaningless on its own. We normally need a balance.

For decorative and industrial enamels and some HDC, OEM, industrial, refinishing coatings etc., cone and plate high shear viscometers are used (5000-10,000 EUR).

Instruments are available that can measure the effect of shear across the whole shear rate range, which can be used to predict the total rheological profile of the coating. They are of course computer controlled and cost in the region of 25,000-100,000 EUR depending on their degree of sophistication.

Measurement

For most coatings a fixed low shear rate (ca 200 s⁻¹) is used to measure the viscosity either in the development or manufacturing/QC stages. There are many versions of paddle type viscometers available (Krebb’s Sturmer, Rotothinner, Brookfield etc.) and the type used varies from company to company and market to market. They tend to cost about 2500-5000 EUR.