Presented at 24th AEMA Meeting, March 14-16, 1997, Cancun, Mexico

Solving Emulsion Viscosity Problems by the Choice of Emulsifier

Alan James, Akzo Nobel Chemicals.

Abstract

Viscosity and settlement are important properties of bitumen emulsions and are specified in most national standards. The paper shows how the choice of emulsifier or the use of bitumen additives can significantly affect emulsion viscosity, and so help to correct problems of too high or too low viscosity.

The mechanisms behind the effects are introduced. In particular the presence of water droplets inside the bitumen particles is related to the viscosity of cationic rapid setting emulsions.

1. Introduction

Emulsion viscosity is an important performance characteristic of bitumen emulsions. In chip-sealing low viscosity emulsions are likely to run off the road, whereas too viscous emulsions may not distribute well over the surface. In open graded emulsion mixes low viscous emulsions may drain off the aggregate. Viscosity is also related to other important properties like settlement - low viscosity emulsions are liable to settle during storage. Therefore it is not surprising that most national standards specify viscosity values and that emulsions can fail to meet their specification because of too low or too high viscosity.

Of the factors which can influence emulsion viscosity most often mentioned are emulsion particle size and particle size distribution [1], the binder content [2], and the presence of salt in the bitumen [3] which can cause viscosity rises during storage of the emulsion. So the focus when trying to solve viscosity problems is most often on the mechanics of the emulsification process and the binder source. Often forgotten is that the choice of emulsifier and other chemical additives can significantly affect emulsion viscosity and often provide a cost-effective way of solving viscosity problems.

2. High Binder Content Cationic Rapid-Setting Emulsions

Cationic rapid-setting emulsions with high binder content are typically used in chip sealing and so viscosity is particularly important. National specifications differ but most require that the viscosity is measured on the hot emulsion, since the emulsions are most often sprayed hot.

Figure 1:Viscosity of Emulsions

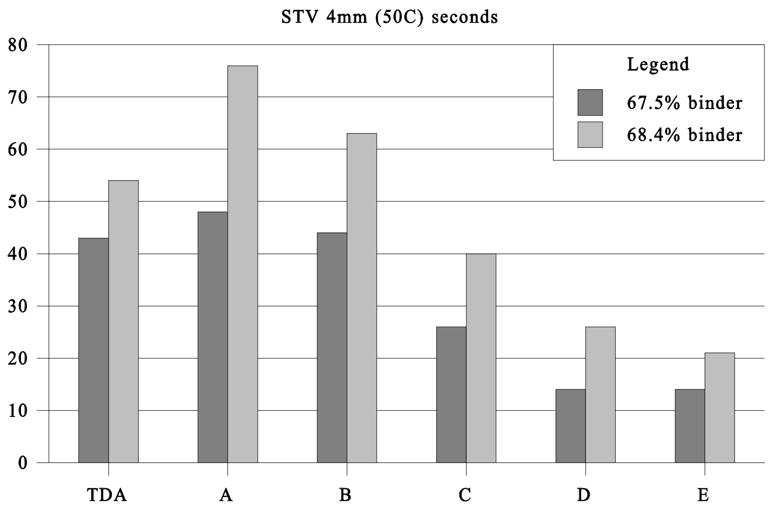
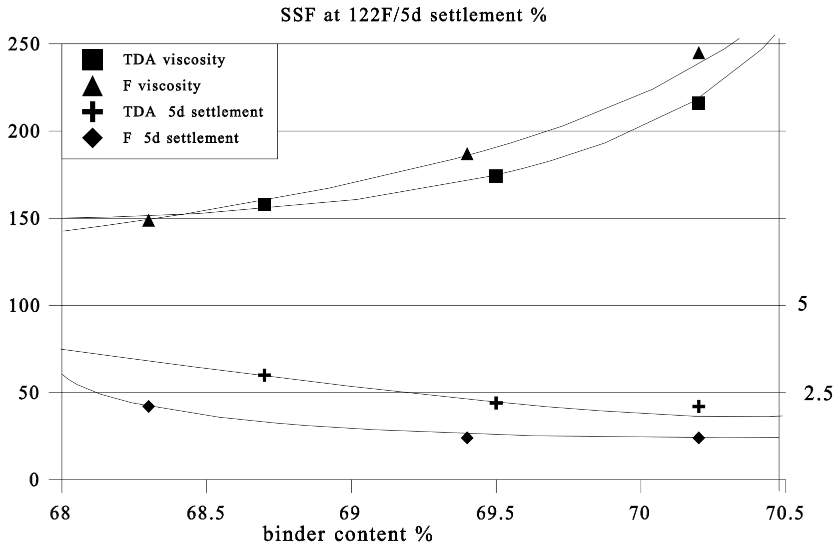


Figure 1 shows the viscosities of emulsions prepared with a range (A-E) of commercially available

Figure 2: CRS-2 Emulsions with paste emulsifiers

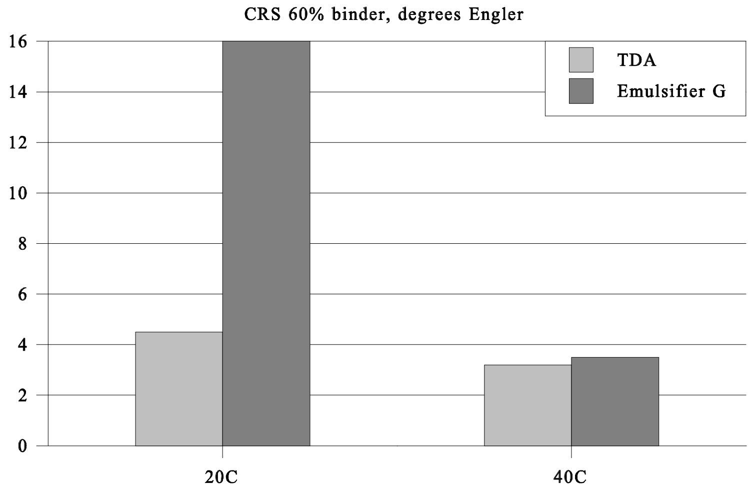


liquid cationic rapid-set emulsifiers expressed in relation to the same emulsion formulation prepared using tallowdiamine emulsifier (TDA) as a benchmark. It is clear that there are considerable differences between the viscosities obtained with the different emulsifiers. It is not a question that one emulsifier is better or worse than another, rather that you can take your choice depending on whether you require high or low viscosity. It is interesting to note that these differences in viscosity between emulsifiers is not primarily an effect on particle size or particle size distribution . All the emulsions shown in the figure had median particle diameters in the range 3.1-3.7 micron. A possible mechanism is discussed below. Figure 2 shows a comparison between the viscosities obtained with two paste type emulsifiers. Again it is clear that the choice of emulsifier is a potential tool in solving viscosity problems. Settlement in the higher viscosity emulsions based on emulsifier F is also reduced. Increasing the binder content will also increase viscosity and reduce settlement, but in comparison with choosing a different emulsifier this is an expensive way to solve problems.

3. Low binder content Cationic Rapid-Setting emulsions

Viscosity specifications for these emulsions typically refer to the viscosity of cold emulsion. Because of the lower binder contents the most common problems are with too low viscosity. Figure 4 shows a comparison between the viscosities of emulsions prepared with tallowdiamine (as benchmark) and a modified diamine (G) at two temperatures. Very substantial higher viscosities can be obtained in this case with the modified emulsifier but the effect is only seen at lower temperature. This is an advantage because it means that the emulsion will pass the viscosity specification but at the same time its viscosity can be reduced by heating in order to spray easily. On cooling the viscosity will again build up on the road surface, preventing run off.

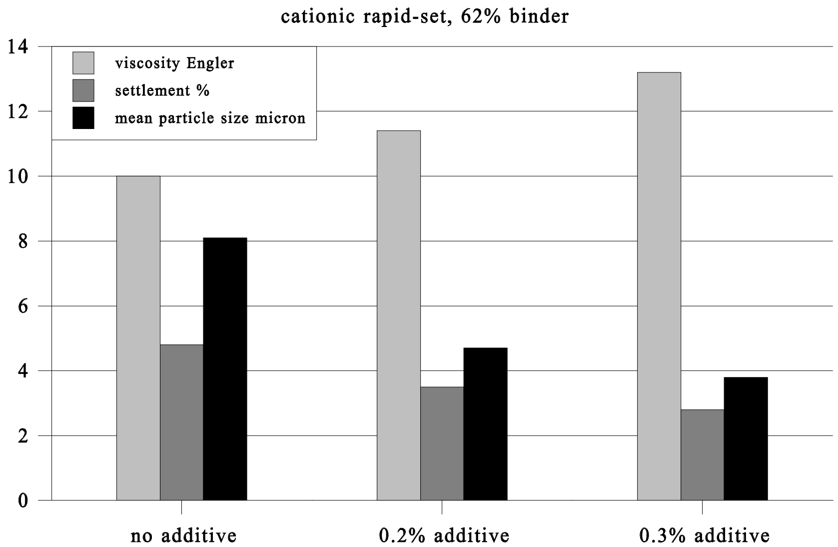
Figure 3: Increased cold viscosity



4. Bitumen additives.

An alternative approach is to use chemicals that are added to the bitumen phase before emulsification. These additives apparently improve the peptisation of the asphaltenes in the bitumen so making the bitumen more easily emulsified [4], and are particularly useful with difficult to emulsify asphalt. Figure 4 shows the effect of an additive on the viscosities of rapid-set emulsions. The benefits in this case generally extend to reduced settlement, and improved emulsion adhesion. Similar results can also be obtained in cationic slow-set formulations.

Figure 4: Effect of asphalt peptizer



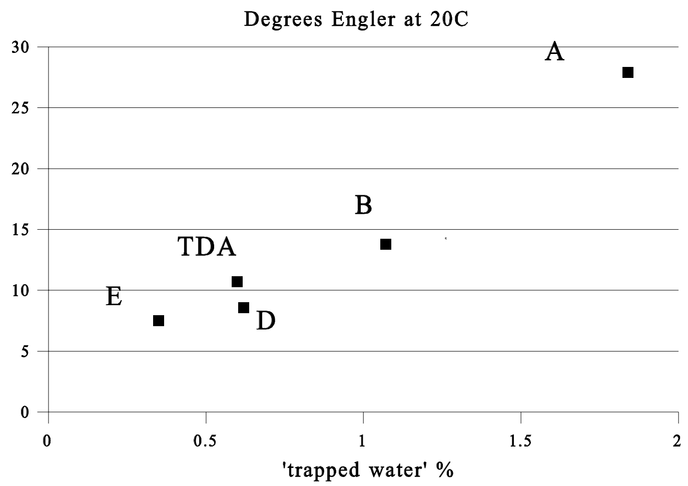
5. Mechanisms of the effects.

In the case of bitumen additives, the effect on viscosity is probably a reflection of the reduced particle size of the emulsion based on treated binder. (Figure 4).

The effect of emulsifiers on the viscosity of CRS emulsions may have a different cause. It has recently been shown that bitumen emulsions are actually of the W/O/W type - the bitumen droplets contain an internal water phase [3,5]. This means that the disperse phase volume fraction (which largely determines the viscosity) is higher than the volume of bitumen by an amount corresponding to the 'trapped water'. The concentration of this 'trapped' internal water phase can be determined by differential scanning calorimetry (DSC) because it freezes at a lower temperature than the 'free' water in the external waterphase [5]. We have found a correlation between the viscosity of emulsions formed using different emulsifiers and the amount of this trapped water (Figure 5). So we believe that the differences in viscosity that we see could be related to the tendency of the emulsifier to form multiphase emulsions

Figure 5: Viscosity and 'trapped' water

67% binder content. Letters refer to the same emulsifiers as in Figure 1



Other emulsifiers can form 'giant micelles' in aqueous solution which have a viscosifying effect similar to water soluble polymers [6]. These emulsifiers can usually be recognised by the high viscosity of their soaps when cool.

6. Conclusion

The choice of emulsifier can be a useful tool to solve viscosity problems. Emulsifiers are available to give higher or lower viscosity. Choosing the right emulsifier is often a more cost-effective approach to reaching specified viscosities than increasing the binder content.

7. References

[1] K. Boussad, C. Lasseur, B. Lombardi, La distribution granulométrique des émulsions de bitume: un paramètre clé pour ajuster leur viscosité, Revue générale des routes et des aerodromes, Hors Série 1, Spring 1995, 72-73

[2] P.Sherman, Industrial Rheology, Academic Press, London 1970, Chapter 3: Rheology of Disperse Systems, pp97-184

[3] R.J.M. Tausk and P.N. Wilson, Colloid Chemical Studies on Bitumen-In-Water emulsions Part 1: Absorbtion of Water in the Bitumen Droplets and Other factors affecting Viscosity, Colloids and Surfaces 2, 1981, 71-80

[4] A.D. James and D. Stewart, A New Quality Improver for Bitumen, Eurobitume Volume 1, 1989, 231-233

[5] P. Claudy, J-M Letoffe, L. Germanaud, and P. Chaverot, Characterisation of Thermal behaviour of Asphalts and Heavy Fuel Emulsions by DSC, 1st World Congress on Emulsions, Paris 1993, paper 1-40-072

[6] J. Myska and P. Stern, Properties of a drag-reducing micelle system, Colloid and Polymer Science 272,1994, 542-547