INFLUENCE OF THE VEHICLE ON THE RHEOLOGICAL BEHAVIOUR OF SCREEN-PRINTING INKS

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1. INTRODUCTION

The screen-printing inks usually employed for decorating ceramic tile are suspensions of frit and pigment particles in a liquid of an organic nature, called the screen-printing vehicle.

Numerous chemical products are currently marketed for this purpose. The present work involves a study of how certain vehicles impact ink behaviour.

2. MATERIALS, EQUIPMENT AND PROCEDURE

With a view to studying the effect of different vehicles on the rheological behaviour of screen-printing inks, a series of experiments were carried out, in which the solids composition was kept constant.

Five commercial vehicles (V1-V5) were tested, and inks were prepared with each (T1-T5).

The flow curve of each vehicle and ink was determined at four temperatures: 10, 20, 30 and 40 °C in a PHYSICA MC-20, concentric cylinder rotational viscometer.

Viscosity (η) was calculated at each point using Newton's generalized law [1], as the quotient between measured shear stress (σ) and shear rate ($\dot{\gamma}$) applied to the sample ($\eta(\dot{\gamma})=\sigma/\dot{\gamma}$).

3. RESULTS

3.1. Influence of the vehicle

Most of the screen-printing vehicles that are currently used contain high proportions of polyglycols with differing molecular weight [2]. However, the use of correcting additives, albeit in small amounts, can modify their behaviour noticeably.

In the studied shear rate interval ($\dot{\gamma}=10^2$-10^3 s^{-1}), the behaviour of vehicles V1 and V2 may be considered Newtonian, since their viscosity was constant. On the other hand, vehicles V4 and V5 exhibited shear-thinning behaviour, as their viscosity dropped on raising shear rates.

Vehicle V3 exhibited mixed behaviour, possibly due to the presence of additives in the composition.

It was shown that the behaviour exhibited by the inks reproduces to a certain extent that of the vehicles employed. The most viscous vehicles yielded the most viscous inks (Fig. 1), whereas the shear-thinning vehicles gave rise to inks with markedly shear-thinning behaviour (Fig. 2), reflected by the fluidity index (n) of Oswald's law ($\eta = K \cdot \dot{\gamma}^{n-1}$). The behaviour observed in the inks was shown to roughly reproduce that of the vehicles used in preparing them.

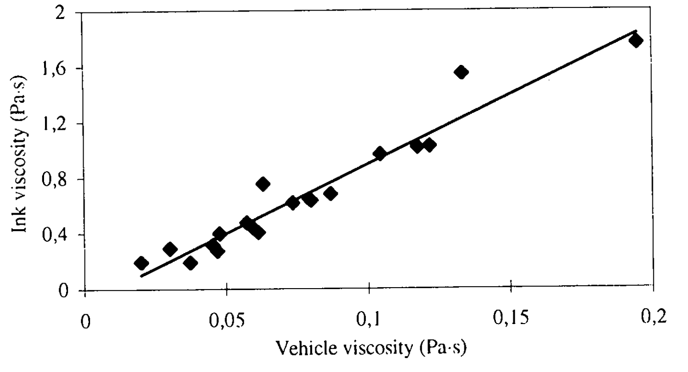

Figure 1. *Relationship between viscosity of the vehicles and viscosity of the inks that they yielded*

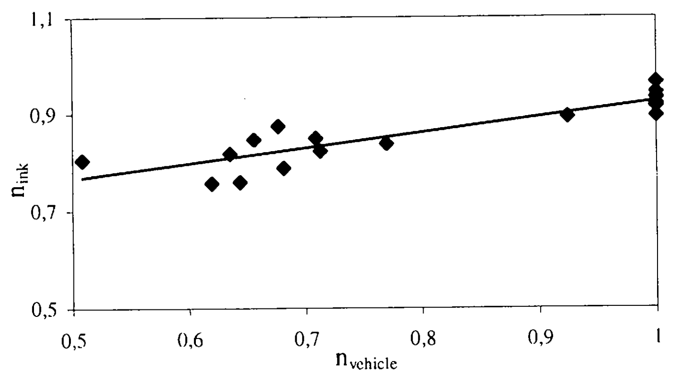

Figure 2. *Relationship between the fluidity index of the vehicles and inks that they yielded. In the inks with Newtonian behaviour, it was assumed that n=1.*

The scatter in the resulting experimental data may be due to the presence of small proportions of additive in the vehicle, which modify frit and pigment particle wetting, and the intensity of colloidal-type interactions.

3.2. Influence of temperature

The temperature interval in which screen-printing inks are used is very wide. If vehicle, and therefore ink, viscosity varies excessively with temperature, it will be necessary to modify their compositions in order to control their behaviour in application, and thus ensure a constant impression [3].

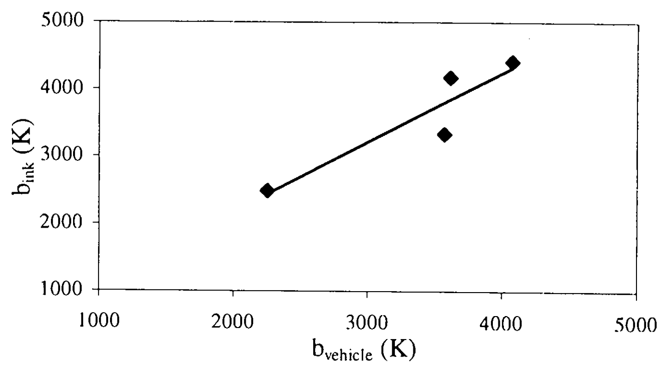

Figure 3. *Relationship between the sensitivity to temperature of the vehicles and the inks.*

The viscosity of liquids and suspensions obeys an exponential law with the inverse of absolute temperature ($T=A{\cdot}e^{b/T}$). The greater or lesser sensitivity of the material to temperature is reflected by the value of parameter b. The variation of vehicle and ink with temperature was shown, and it was confirmed that the greater the vehicle's sensitivity to temperature, the greater was the variation in the ink (Fig. 3). The inks prepared with vehicle V3 differed from the general trend, possibly owing to the additives used.

4. CONCLUSIONS

The tested screen-printing inks cover a wide range of viscosities, and may exhibit shear-thinning or Newtonian behaviour. The vehicle's type of behaviour influences ink behaviour, although this behaviour cannot be exactly predicted as a result of the complexity of interface phenomena in non-aqueous systems.

Rising temperature lowers viscosity in the vehicle and therefore in the inks. The vehicles exhibiting the greatest variation in viscosity with temperature yielded inks in which this variation was also high.

The selection of a vehicle cannot be solely based on its viscosity, rather it is the type of targeted rheological behaviour which must be taken into consideration, with its variation with temperature, as well as its own stability.

5. REFERENCES

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