# DEVELOPMENT OF AQUEOUS-BASED INKS FOR CERAMIC TILE SCREEN PRINTING DECORATION

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## 1. INTRODUCTION

Glycols are the major components of the vehicles used in screen printing decoration[1]. Their use involves one of the main contributions in organic matter to the ceramic tile manufacturing process, which causes technical problems (increased black core) and environmental problems (higher COD and BOD in recycled water and a rise in volatile organic compounds, VOCs, in kiln gas emissions).

With a view to reducing these problems, the present study was undertaken with two objectives. First, to develop screen printing vehicles in which water was the major liquid component (quantity equal to or exceeding 50% by weight). Secondly, to prepare screen printing inks with these vehicles, which could be applied in the ceramic tile manufacturing process.

## 2. EXPERIMENTAL

Vehicle preparation was carried out using industrial raw materials such as polyglycols with a low and high molecular weight, glycerine, cellulose ethers and water. The following determinations were performed to characterise the vehicles: surface tension (drop tensiometer), suction rate (suction constant) found using a standard fired body, flow curve (rotational viscometer) and evaporation rate. The evaporation rate was assessed by subjecting a vehicle sample for a certain time (24 hours) to ambient conditions of 50°C and 50% relative humidity in a climatic chamber.

## 3. RESULTS

### 3.1 SELECTION OF VEHICLE COMPONENTS

On adding quantities of water exceeding 25% by weight to a standard polyglycol (e.g. PEG-400), a remarkable decrease in viscosity and a significant rise in suction and evaporation rate of the resulting vehicle was observed. Surface tension did not exhibit any significant variation in the studied composition range. The observed drop in viscosity could favour an increase in density (solids load) of the screen printing ink. The increase in suction rate could also be considered beneficial for the decorating process, since it allows accelerating production and improving the quality of the coating. However, if the evaporation rate is too fast, ink consistency could rise excessively during application, leading to progressive screen clogging and consequently to inadequate ink deposition on the piece.

To reduce vehicle evaporation different solvents were tested, which on mixing with water lowered the vehicle evaporation rate. The tested solvents were: polyglycols of low molecular weight, such as monoethyleneglycol (MEG), diethyleneglycol (DEG), triethyleneglycol (TEG), and polyethyleneglycol 400 (PEG-400), propyleneglycol (PG), glycerine (G), sorbitol (S) and a polyalkylglycol of molecular weight exceeding 2000 (PAG). Additives with a high water retention capacity were also tested: cellulosic derivatives such as hydroxyethylcellulose (HEC), methylhydroxypropylcellulose (MHPC) and methylhydroxyethylcellulose (MHEC), sodium alginate (ALG-Na), polypropyleneglycol alginate (ALG-PG), and a bentonite (B).

It was observed that the evaporation rate (evaporated quantity of water 60 min after experiment start) of the tested compounds varied according to the following sequence: G<MEG<PAG<DEG<S<TEG<PG<PEG400. The sequence found for 0.5 wt% solutions of additive was as follows: MHPC<MHEC<HEC<ALG-Na ≅ ALG-PG<Bentonite. For the same cellulosic derivative the water retention capacity was found to increase with molecular weight.

### 3.2 SCREEN PRINTING INK PREPARATION

Screen printing inks were prepared using standard industry materials and working conditions. The vehicles were formulated using the solvents and additives that had exhibited the largest water retention capacity: glycerine and polyalkylglycol of high molecular weight (together with monoethyleneglycol and PEG-400 as diluters) and methylhydroxypropylcellulose. Combining these ingredients two screen printing inks were prepared using two vehicles that contained 50 wt% and 75 wt% water (V50 and V75)[2]. These inks were respectively referenced T50 and T75.

First the COD was determined of vehicles V50 and V75. This was found to be between 2 and 3 times less than the COD of current vehicles.

Subsequently, after verifying on a laboratory scale that the characteristics of the formulated inks (rheological behaviour, stability and behaviour during application) were appropriate, industrial trials were undertaken. Lots of approximately 3000 $m^2$ of stoneware floor tile were manufactured. After the relevant adjustments of the working conditions, appropriate ink behaviour was observed, obtaining first choice percentages comparable to the usual rates found at the company where the trials were carried out. Finally, it was found that in the industrial tiles which had been stored before firing, the thickness of the black core in the fired tile decreased proportionally to the quantity of water contained in the vehicle.

## 4. REFERENCES

[1] SANZ, V.; SÁNCHEZ, E.; BOU, E.; TIRADO, M. Influência da serigrafia sobre a variação de tonalidade de revestimientos cerâmicos. *Cerâmica Industrial*, 4(16), 19-26, 1999.

[2] AICE, et al. Vehículos y tintas serigráficas en base acuosa. Spanish Patent application no. P200100390, 2001-02-21.