Greener Hydrophobic emulsions for application in the automotive industry

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Introduction/Objective

A superhydrophobic surface facilitates easy cleaning and prevents corrosion, making it highly attractive in the automotive painting industry for extending the service life of paint coatings on equipment and metal surfaces by providing resistance to corrosion, wear, and cracking (Wu *et al*.,2017; Mirchandani *et al*., 2022). However, superhydrophobic materials often involve complex synthesis, processing challenges, and limited stability (Wu *et al.,* 2017). They are typically prepared using fluorinated monomers, which are associated with environmental concerns (Mirchandani *et al.,* 2022). Emulsion polymerization appears as a greener approach to solvent polymerization since water is used as solvent. Also, the possibility of application as films is quite adequate to coating area. As for the substitutes of fluorates, acrylates, have been used to provide some flexibility through the aliphatic chains (Morsi, 2023) and present good water and corrosion resistance (Al-Qahtani *et al*., 2022).

In this study, an efficient and environmentally friendly water-based emulsion free from fluorinated monomers was developed to protect automotive paint booths, robots, and other equipment from the effects of "overspray."

Results

Two water-based emulsions were prepared, one using styrene and acrylates (E1) and another using styrene, acrylates and methacrylates (E2). A solid content around 41-49% was obtained and some of the characterizations were made on film. The emulsions presented stability along three months after the use of an additive (TiO_2).

Surface morphology of the films

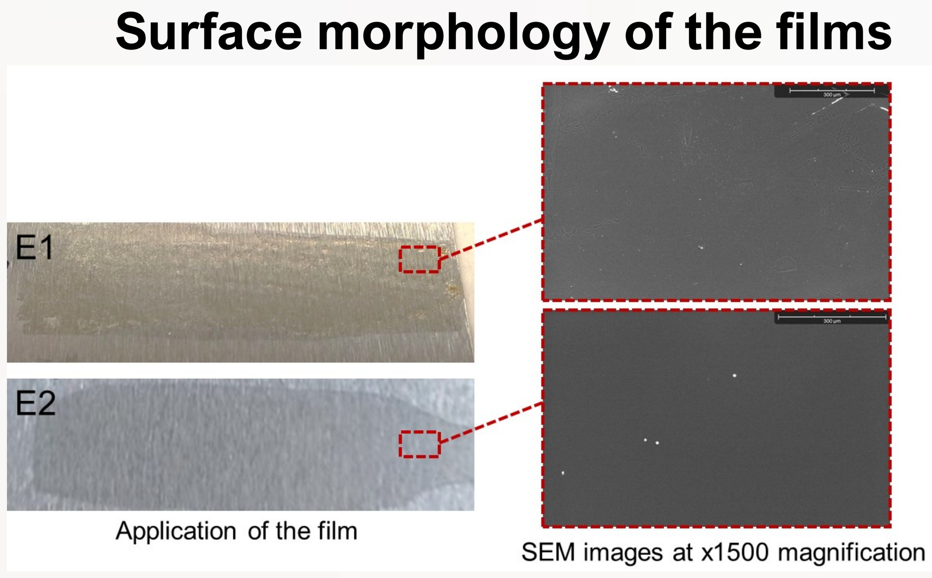

Figure 1. Films made out the synthetized emulsions (left) and SEM images at a magnification of x1500 from the same films.

The formation of the film indicates a smooth and uniform surface (Figure 1).
SEM analysis was performed to confirmed the formation of a **continuous film**.

Water contact angle of the films

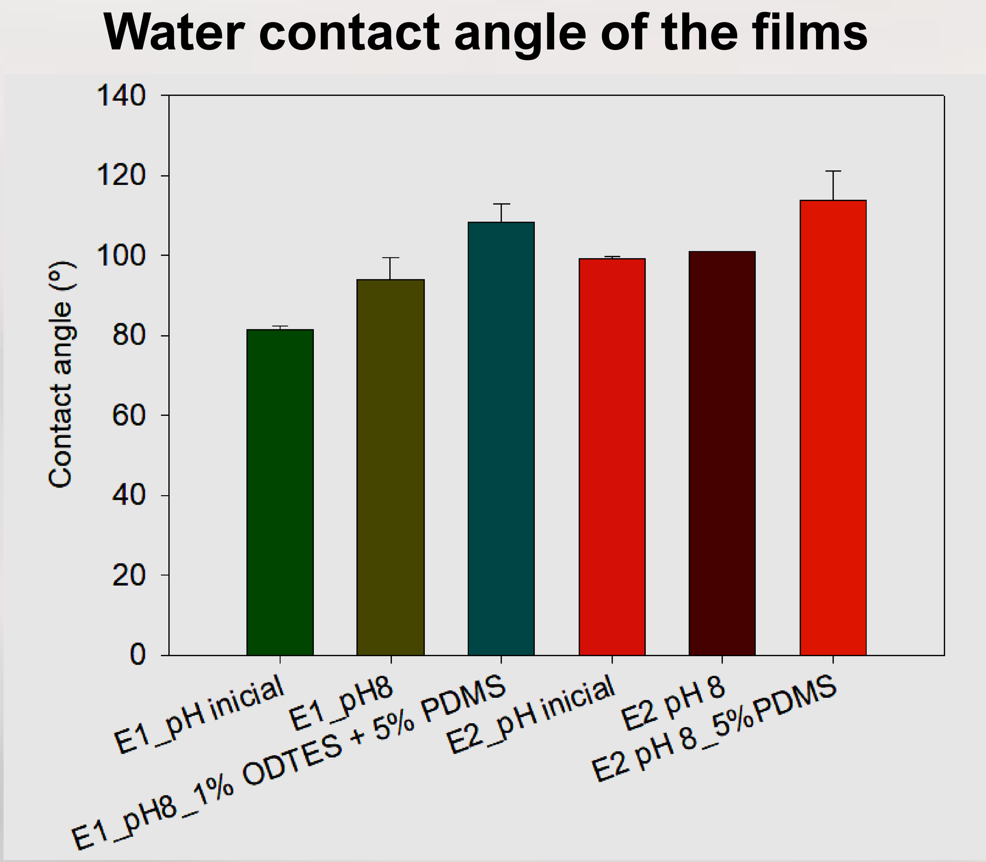

Figure 2. Values of contact angle obtained for the emulsions synthetized.

- All formulations presented angles above 90º (Figure 2) indicating the achievement of hydrophobicity for the coating application.
- Formulation **E2 presented higher values**, having a more hydrophobic effect.
- Some additives were tested with the emulsions. The best formulations presented **angles above 110º**.

Thermal and stability properties of the films

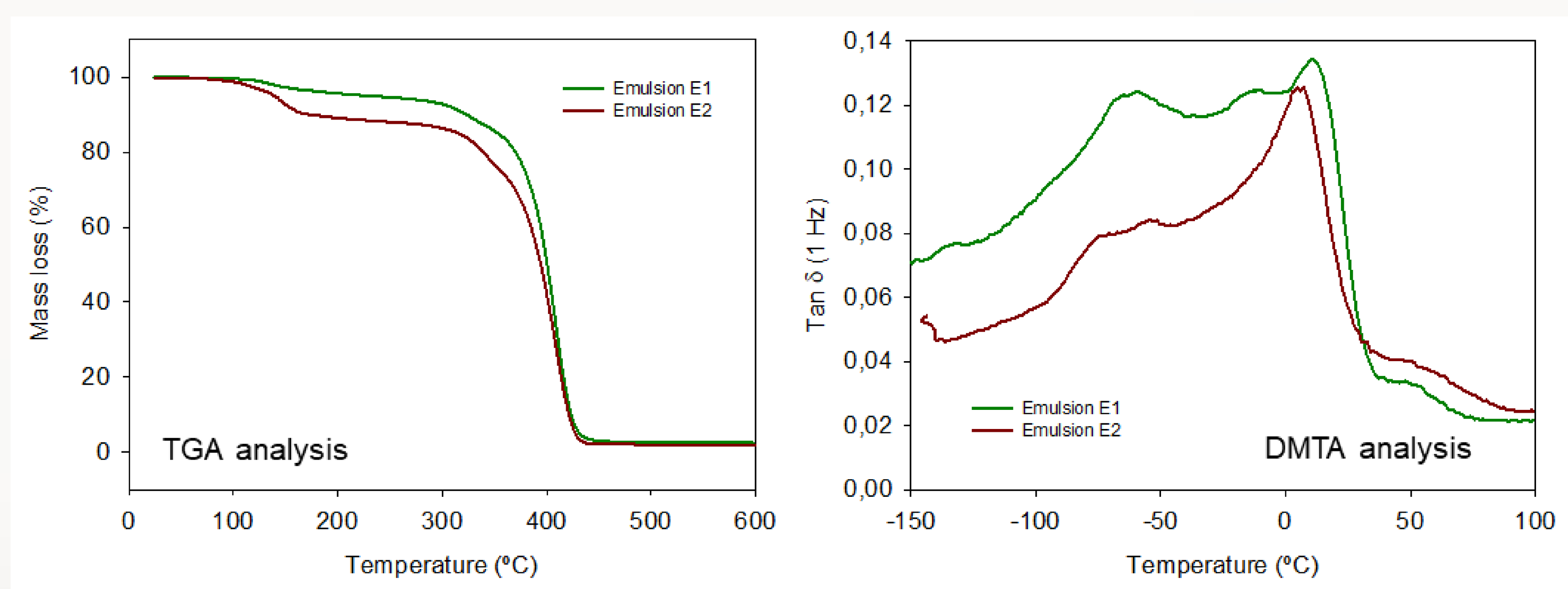

Figure 3. Thermal profiles obtained for the synthethized emulsions.

Table 1. Summary of the results obtained for the synthethized emulsions.

Sample	T_{onset} (TGA)	$T_{5\%}$ (TGA)	T_g (DMTA)	Particle size (1 day) (nm)	Particle size (3 months) (nm)
E.1.	391.7ºC	232.8ºC	-60.7ºC/9.3ºC	107±8.92	119.7±0.41
E.2	382.6ºC	139.4ºC	-54.1ºC/5.7ºC	146.3±16.05	91.74±0.2

- The particle size obtained didn't increase over time, so no agreggates were formed (stability ensured);
- In **TGA analysis**, it is possible to see that the emulsions are quite stable until high temperatures since the degradation of both occurs near the 400ºC (Table 1);
- There is a substancial mass loss above the 100ºC (Figure 3). Random breaks of the main polymeric chain can release monomers and cause that phenomena.
- The **DMTA analysis** showed the presence of two glass transitions, one negative (respoonsable for flexibility) and another one positive (brings resistance to abrasion);

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Conclusions

The emulsions were prepared by a straightforward method and the films obtained from the emulsions casting showed promising results. The T_g values gives good mechanical properties since the lower T_g confers flexibility needed to apply as coating (easy to form continuous films) and the higher T_g ensures the resistance of the film. Also, contact angles above 110º were achieve, ensuring the hydrophobic effect.

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