Development and characterization of a nail polish formulation based in polystyrene nanoparticles as a novel excipient for cosmetic use.

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Introduction

Polystyrene nanoparticles (NP's) were prepared from recycling materials stabilized by a polymer surface agent (PVA) by emulsification- solvent desplacement method. The particles size was from 270 to 279 nm with a polydispersion index (IPD) of 0.213 to 0.263. They showed good stability obtaining a zeta potential (PZ) value of -19.7 to -25.2. The aimed of this study is the use these dispersions as film-forming nail polish
agents, evaluating their ability to create a continuous layer, where the influence of plasticizers in relation to dispersion was also evaluated.
Previously, a study was carried out evaluating the ideal concentration of plasticizer on the physical properties of the film, in a range of 10, 25, and 50%. The films obtained were characterized by scanning electron microscopy (SEM), differential scanning calorimetry (DSC), and tensiometer evaluations.

Materials & Methods

NPS elaboration

Ethyl Acetate (AcoEt) and water were mutually saturated for 1 min before use to ensure both t liquids' initial thermodynamic equilibrium. Then, typically, 200 mg of Polystyrene (PS) were dissolved in 10 ml of saturated ethyl acetate, and this organic solution (internal phase) was emulsified with 20 ml of a 5% w/v PVA water-saturated aqueous solution (dispersion medium) using a high-speed homogenizer (Ultra-Turrax T 25, IKA Lab-Technik, Germany) at 8000 rpm for 10 min. After an oil-in-water emulsion, it was transferred to a rotary evaporator and evaporated for 30 min at 35°C until the organic solvent was removed entirely.

Particle size and polydispersity index (IP)

Mean diameter and size distribution were measured by photon correlation spectroscopy (DLS) with a Coulter Nanosizer N4. All measurements were performed at 25 ◦C. The values were calculated from the measurements performed at least in triplicate.

Zeta potential (ZP)

The surface charge of nanoparticles was characterized in terms of ZP using a Malvern Zetasizer.
All measurements were performed with 10 runs at 25 °C, and results are reported in terms of ZP ± SD (n=3).

Effect of plasticizers on nanoparticles dispersion films

Pilot batches were prepared to incorporate different plasticizers agents at a variable speed with a mechanical stirrer at 240 rpm for 10 minutes (IKA Ultraturrax T-50). A comparison was carried out (50% based on the amount of polystyrene referred to as 100%). The prepared samples were poured into Teflon molds, 36 ml with an area of 169 cm3 allowing the formation of the film by evaporation of water. Later, they were extracted from it to evaluate the deformation capacity (Figure 1).

Morphological characterization of the samples was performed using the scanning electron microscopy analysis (SEM modality) to visualize the particles in solid form. The analyses were performed in high-vacuum conditions.

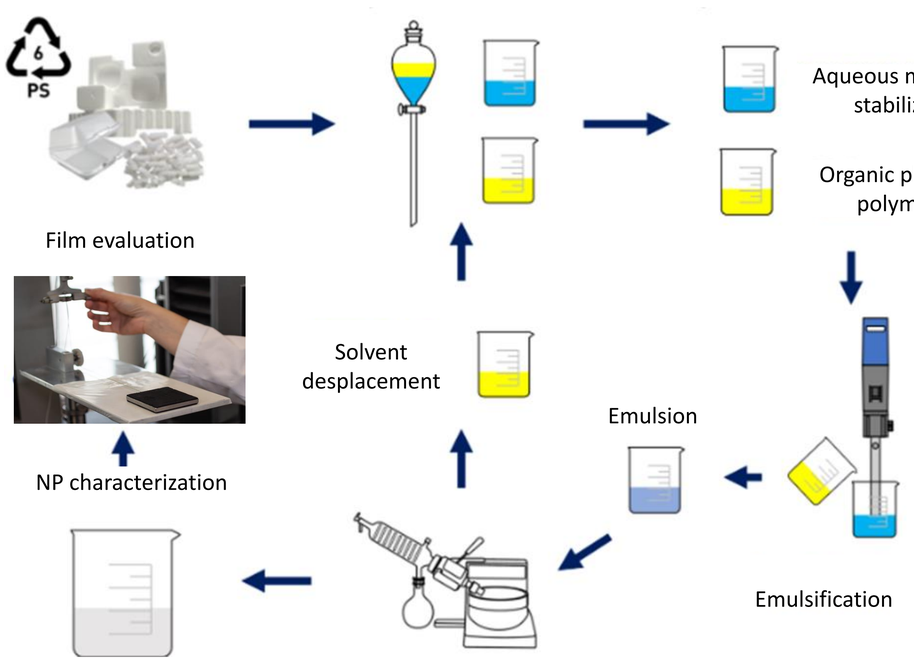

Figure 1. Methodology of the Polystere nanoparticles fabrication and nail polish film evaluation.

Conclusions

The polystyrene nanoparticles were obtained by a scaling-up and straightforward process from waste polystyrene in a reproducible way with narrow particle size. However, this dispersion formed a continuous film with poor mechanical properties. A linear behavior was observed in the decrease of the Tg with the increase of the concentration of the plasticizing agent for the tensiometer; on the contrary, it was the lower amount of glycerin that showed a greater elongation capacity and a greater force to achieve rupture. This formulation's goal was to use a recycling material, one of the most common in pollution, making itvaluable and economical. In addition, aqueous dispersions of this material can have important implications in different industries, including the cosmetic.

Results & Discussion

The results of the characterization of the polystyrene dispersions are summarized in Table 1

Table 1 Nanoparticles properties

Sample	Particle size (nm)	Polidispersity Index	Potential Z (mV)
Blank	274.0 + 9.40	263 + 0.015	-25.2 + 1.0
Blank + Sudan	3270.8 + 10.6	0.213 + 0.011	-19.7 + 1.3
Blank + antraquinone	279.4 + 17.8	0.254 + 0.019	-20.4 + 0.3

The morphology of the nanoparticles shows that their monodisperse size can be able to generate homogeneous stable films. To determine nanoparticles size and shape and potencial applications (Figure 2) polystyrene nanocapsules were prepared with colorants as the oil phase to determinate a variation on their structure.

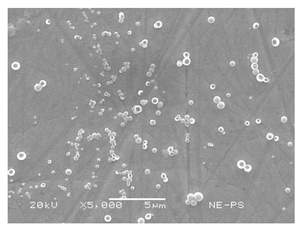

Figure 2 Polystirene nanocapsules size and dispersity

Particle size were around 270 to 279 nm and a polydispersity index of 0.213 to 0.263, which suggests narrow distribution. Potential Z can estimate nanoparticles stability which values are around -20 to -25 mV, according to this value the dispersion shows a good stability. Triacetin, D-limonene. Polyethylene glycol 200 and Glycerin were evaluated at different concentrations. Triacetin and D-limonene did not show flexibility to the film (Figure 3). Glycerin and PEG, showed the ability to confer flexibility of the film. This good acceptance towards polyols by the formulation is attributed to their compatibility with PVA.

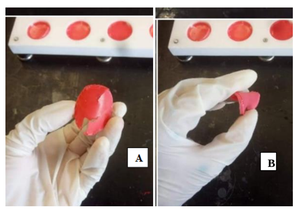

Figure 3. Effect of different plasticizers on polystyrene nanoparticlers film. A (D-limonene, Triacetin) B (Glycerin, Polyletyleneglicol).

Morphological dimensions shows, PS nanoparticles uniformity at high magnification (10,000 X) using the SEM technique. PVA promoves the film formation due to its excellent barrier properties since it is dense and very compact.

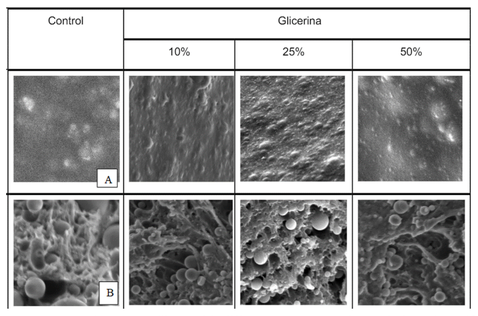

Figure 5 Scanning electron microscopy to polystyrene films with different concentrations of glycerin at 1000x. films surface (A) transversal size of (B)

The results show the average of the width with different concentrations of plasticizers; glycerin 50% was the film with the highest width, Young modulus and TEB does not have tendency between different concentrations with no statistical differences. The use of glycerin as a plasticizer can be an economic, environmental friendly material which does not modify the properties of the film making a potential nail polish.

Table 2 Tensiometer values for the different concentrations of plasticizer.

Sample	Parameters		
	width	Young modulus (mJ)	TEB (mm)
Blank	20 mm	189.5 ± 43.41	5.36 ± 0.61
Glycerin 10%	22 mm	400.43 ± 71.55	18.27 ± 1.66
Glycerin 25%	30 mm	92.7 ± 20.38	11.63 ± 3.8
Glycerin 50%	37 mm	144 ± 25.34	16.48 ± 2.56

Aknowledgments

The research was funding by PAPIIT IN222420 and IN222520 from DGAPA-UNAM and PIAPI2040.

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