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PREPARATION OF ASPHALT EMULSIONS STABILIZED WITH POLYSTYRENE NANOPARTICLES OBTAINED FROM RECYCLED MATERIAL

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Abstract: Asphaltic emulsions stabilized with solid particles have potential advantages over conventional systems, which are formulated with surfactants which tend to be less stable and more toxic than solid particles. This kind of liquid-liquid stabilization is known as Pickering emulsions that can be aligned with basic sustainability principles. This study assessment the feasibility of using polystyrene nanoparticles to prepare Pickering asphaltic emulsions. The nanoparticles were obtained of solid urban waste materials called expanded polystyrene foam by emulsification and solvent displacement method which allowing of reuse of the solvent, being a total green process. Size of asphaltic globules was reduced according increased the concentration of polystyrene nanoparticles, until certain concentration. To 30 days of storage all asphaltic emulsions did not show phase separation or creaming.

INTRODUCTION

Asphaltic emulsions have two important advantages: reducing environmental pollution and lowering energy consumption because they do not require heating for conventional applications.[1-3] If these emulsions are stabilized with solid particles great benefits can be achieved such as lesser, or even eliminate the use the surfactants, protecting the environment, are safer for users, and forming systems with excellent stability, among other advantages.[4-7] Various types of nanoparticles could contribute to stabilization asphaltic emulsions. This mechanism is generally called *Pickering* stabilization. It has the potential to further enhance the properties of asphaltic emulsions by providing greater stability and ease handling.[8,9] Chen & Li[10] conducted a comprehensive study of the *Pickering* stabilization mechanism using SiO_2 nanoparticles modified with a polycondensate. The nanoparticles were absorbed onto the surface of asphalt particles, giving a emulsions with excellent stability. They also observed a slight decrease in ductility; however, the Nano-SiO_2 emulsified asphalt meet established specifications, and the issue of ductility requires additional research.[10] Li et al.[11] deduced that asphaltic emulsions stabilized with Nano-SiO_2 extended storage time due to improved physical stability compared to conventional asphaltic emulsions.[11] Tabatabaie & Tabatabaie[12] analyzed the use of clays in asphaltic emulsions, finding that they gave good stability and enhanced control.[12] James & Zhou[13] studied bentonite clay as a stabilizer for asphaltic emulsions, obtaining results that show significantly higher softening points and lower penetration on tests of the residues from the emulsions.[13]

METHODOLOGY

PREPARATION OF ASPHALTIC EMULSIONS STABILIZED WITH POLYSTYRENE NANOPARTICLES

Ergon bitumen grade 64–22 obtained from the PEMEX refinery in Cadereyta and with viscosity of the order of 0.522 Pa·s at 135 °C and penetration of 78 (25 °C, 10 mm−1) was used as asphalt model. The bitumen hot at 150 °C (previously weighed at 40, 50 and 60% w/w) was added to hot polystyrene nanoparticles dispersion[14] (40 °C) at different concentrations (1–2.8% w/w) to a colloid mill (Benedict Slurry Sea colloidal) by few seconds. The emulsions formed had residues of 40, 50 y 60% w/w. In all cases, the samples were softly stirred using a glass rod before each test, avoiding globules breakup by a vigorous agitation. Each sample was identified according to asphalt contents and their stabilizer concentration.

PARTICLE SIZE ANALYSIS

The average and their distribution Particle Size were determined using the laser diffraction technique on a laser scattering particle size distribution analyzer (HORIBA's LA-350).

MICROSCOPIC EVALUATION OF THE PICKERING ASPHALTIC EMULSIONS

A small sample is taken from the stable emulsified asphalt and placed as a thin film on a glass plate. Immediately after it is dried for some minutes, the specimen is observed to the optical microscope for study.

TEST OF SIEVE RESIDUE OF PICKERING EMULSIFIED ASPHALT

The analysis and study the sieve test of oversized globules or other discreet solid (asphalt residue) was followed- up by the standard N·CMT·4·05·001. Generally speaking, once emulsions were prepared, between 800–1000 g were collected in a 1000-ml glass recipient, passing this simultaneously on a 850-μm mesh sieve previously weighed. The sieves were heated at 105 °C by two hours, after sieves reach atmospheric temperature, the percentage corresponds to the fraction was calculated that was retained in the sieve.

TEST OF STORAGE STABILITY OF PICKERING EMULSIFIED ASPHALT

The percentages corresponding to the subtraction between the percentages of residue from the bottom sample minus the percentage of the residue from the top sample which were obtained collecting 50 g from the bottom and 50 g top of glass test tubes, collected in a 1000-ml glass recipient, previously weighed with a glass rod. Then the water was evaporated at 163 °C by two hours, and for one more hour after homogenizing the samples.

RESULTS

After the emulsification process, polydisperse emulsions were obtained (Figure 1) with a wide size distribution ranging from 5.9 to 20.1 μm (Table 1). Some emulsions exhibited a bimodal globules distribution. This could be due to the mechanical parameters or to the composition parameters of the emulsion formulation. We have observed that it could be a possible increase in the concentration of polystyrene nanoparticles; however, we will must be explored some mechanical parameters too. Nevertheless, this can be understood if we mix two asphalt emulsions with different unimodal globules size distributions; the emulsion will have a bimodal globules distribution as a consequence an emulsion with viscosity reduction can be obtained, because smaller globules could be distributed between the larger globules, decreasing interaction between them.[15]

The stability of Pickering asphalt emulsions has been monitored visually, observing that to over 30 days old, all systems remain without breakup by chemical destabilization. Even some emulsions are more than 60 days old; see Figure 2.

As is clearly shown in the micrographs of the Figure 3, the asphalt particles in the polystyrene nanoparticles emulsified asphalt are distributed uniformly. There is little particle agglomeration without forming chain or block aggregates. In summary, this observation suggests that the polystyrene nanoparticles in emulsified asphalt can have desirable stability against agglomeration. In addition, helps form the spatial steric hindrance among the asphalt particles that prevent the emulsion breaking and particles conglomerating.

Some of the more common physical properties are shown in Table 2. The percentage of residue (Figure 4) in some

Fig. 1 Colloid mill used to reduce asphalt particle size and emulsify it.

Testitems/ Sample	40-1	40-2	50-1	50-2	50-3	60-1	60-2
Meansize	5.90	13.85	14.15	10.37	14.11	12.43	20.14
Span	0.97	1.47	1.28	1.26	1.46	1.33	2.00
Distribution	Unimodal	Bimodal	Unimodal	Unimodal	Bimodal	Unimodal	Bimodal

Table 1. Data of particle size and distribution.

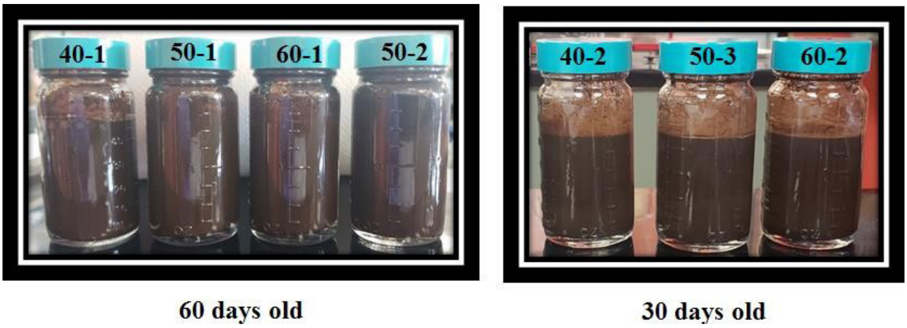

Fig. 2. *Pickering* asphalt emulsions stabilized with polystyrene nanoparticles obtained from recycled material.

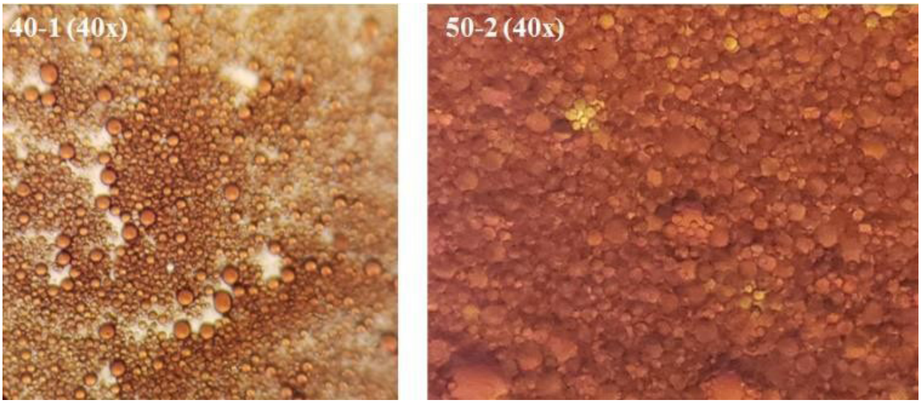

Fig. 3 Optical micrographs of *Pickering* asphaltic emulsions stabilized with polystyrene nanoparticles.

Testitems/ Sample	40-1	40-2	50-1	50-2	50-3	60-1	60-2	Technical requirements
Sieveresiduetest(%)	0.02	0.39	0.07	0.18	0.04	1.51	0.02	≤ 0.1
Storagestability test(5d,%)	-	12.7	-	-	2.9	-	<1	<5

Table 2. Testing results of the *Pickering* emulsified asphalt.

Fig. 4. Mesh of test of sieve residue of the sample 40-3.

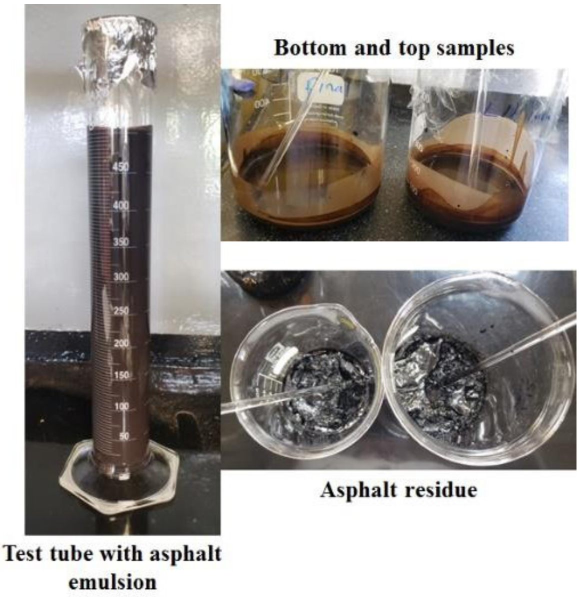

Fig. 5. Test of storage stability at 5 days.

emulsions were satisfactory, this is the physical stability compared with the technical requirements indicated compliance with the parameter. Therefore, it can be considered that emulsified asphalt modified by polystyrene nanoparticles may be a good physical stability, and can meet some specification requirement. On the other hand, storage stability test shown some satisfactory results (Figure 5).

CONCLUSIONS

Expanded polystyrene foams can be treated by recycling to help reduce the problem of urban waste. This recycled material was performed to produce polystyrene nanoparticles, as an alternative in the treatment of solid urban waste, generating a value-added product with broad potential in the field of construction such as pickering asphaltic emulsions, that contribute to mitigating environmental pollution. In addition, solvent recovery for use in new batches of polystyrene nanoparticles can also benefit the environment. Preliminary results showed stable emulsions for more than 60 days. The emulsions were prepared with percentages of asphalt of 40, 50 and 60%. The average particle sizes were between 5.9 and 20.14 μm and it was increase in accordance with the increase in the percentages of asphalt. The concentration of the nanoparticles was a key factor in the size of asphaltic globules. Much remains to be confirmed, however, key findings were found which reported in this summarized.

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