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Zeolitic rock as a new pigment for ceiling paints. Influence of the pigment volume concentration

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Abstract

The performance of a zeolitic rock, mainly clinoptilolitic (heated at 350 °C) is studied as humidity and ammonia adsorber in ceiling paints. The paints were formulated with 39% and 75% of zeolitic rock by volume of the total pigment content and 75% and 85% pigment volume concentration (PVC). A blank, without zeolitic rock, was also formulated. The performance of the paints were assessed by gas (water and ammonia) adsorption and adsorption–desorption cycled tests. The results show that the paints containing zeolitic rock have better performance than the blank. Moreover, paints with 75% PVC behaved better than paints with PVC 85%. This behaviour may be due to the higher pigment content because the paints with PVC 85% retain more water during the curing period diminishing their adsorption capacity.
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1. Introduction

Zeolites are hydrated alumino-silicates of the alkaline and alkaline earth metals. Their structures have Si–O–Al linkages that form surface pores of uniform diameter and enclose regular cavities and channels of discrete sizes and shapes, depending on the chemical composition and crystal structure of the specific zeolite involved [1]. One of the most important characteristics of the zeolites is that they can adsorb water, as well as some interchange cations, in a reversible way without important changes in their structure [1]. It is well established that the multiple uses of these materials are based on their physicochemical properties, which explain their wide range of application in numerous agricultural and industrial areas [2–5].

The ability of activated zeolites to adsorb certain gases readily lends them to odor control application (public toilets, horse stables, chicken houses, feed lots and pets litter) and for the purification of gaseous flows, including gases containing substances of acidic nature [3,6].

The use of synthetic zeolites in paint technology was reported some years ago as humidity adsorber in order to improve the dryness of a polyuretane film or added to a paint to retain the anti-microbial properties of a biocide [7,8].

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2. Materials and methods

A natural clinoptilolite-rich tuff from La Rioja province (Argentina), heated at 350 °C, was used in all of the experiments. The rock was used in its natural state and it is representative of the deposit in terms of mineralogical composition and chemical and physical properties.

The natural zeolitic rock was heated at 350 °C for 4 h in order to remove all the water molecules adsorbed in their cages and channels [9]. This temperature was selected because in a previous paper was seen that the heated zeolitic rock have a better performance in ceiling paints than the natural rock. This treatment activates the zeolite and thus, molecules with diameters smaller than the channels are adsorbed in the dehydrated cages [9].

Plaster when is fresh or ''green'' is alkaline in reaction and must either be sealed with an alkali-resistant sealer prior to painting with a conventional paint, or painted with a special alkali-resistant paint. At the present time, special paints having such binders as chlorinated rubber or acrylic latex paints are used [10]. The pH of a water suspension of the heated zeolitic rock, measured after 24 h in contact, was near 8, therefore, it could be used as a pigment in plaster paints.

Acrylic panels were painted and kept in a desiccator at 25 °C up to constant weight. This occurred at 15 days of essay.

3. Experimental

The material employed to form the paint film was a water-based acrylic/styrene resin. Two PVC (Pigment Volume Concentration) were used: 75% and 85% [11].

Two different contents of zeolitic rock were employed to formulate the paints: 39% and 75% volume/volume with respect to the total pigment concentration. Titanium dioxide, natural calcium carbonate and precipitated calcium carbonate were incorporated to complete the pigment formula. Natural calcium carbonate was completely replaced by the heated zeolitic rock in the paint with the higher zeolite content. The composition of the paints, by volume, is shown in Table 1.

Paint manufacture was carried out employing a high-speed disperser unit. A dispersion of cellulosic hardener in distilled water was added to a dispersion of additives such as anti-foaming and dispersants also in distilled water employing a disperser. After that, the pigments were added. Then the resin and the coalescents were also incorporated.

Acrylic panels of $7.0 \times 10.0 \times 0.2$ cm were painted, on both sides, by means of a brush up to a dry paint weight of around 9 g. Before testing, the panels were kept in a desiccator at 25 °C for 15 days.

Table 1
Composition of the paints (% by volume of solids)

Components	Paint A	Paint B	Paint C	Paint D	Paint E
Titanium dioxide	16.6	16.6	18.7	18.7	16.6
Calcium carbonate (natural)	27.1	–	30.4	–	53.8
Calcium carbonate (precipitated)	2.1	2.1	2.8	2.8	4.8
Zeolitic rock	29.4	56.5	33.0	63.4	–
Resin	24.8	24.8	15.1	15.1	24.8
PVC (%)	75	75	85	85	75
Zeolitic rock content/ pigment content	0.39	0.75	0.39	0.75	0.00

4. Essays on the painted panels

In order to determine the humidity and ammonia adsorption of the paints, adsorption tests were carried out during a week. Painted panels were placed either in a closed environment with a 79.5% of humidity or in an ammonia saturated environment, at 20 °C [12]. The panels were weighed before the test in an analytical balance, and during different periods of time, up to a week.

As the coating should be sufficiently permeable to water vapor to allow any moisture that does penetrate to escape, enabling the substrate to dry out, cyclic essays of adsorption–desorption of humidity and ammonia were also performed. In the case of water adsorption–desorption test, the panels were placed in a 79.5% humidity environment for 24 h and then exposed to a 37.1% humidity environment. They were weighed at the beginning of the essay and after 3 and 24 h, in each environment. The results are shown as percentage of water or ammonia referred to the original dry paint weight.

Similar essays were carried out in a gas saturated environment and in an environment without the gas, using ammonia as adsorbate.

5. Results and discussion

As can be seen in Fig. 1, at the beginning of the essay (24 h in the 79.5% humidity chamber) paint D was the one which adsorbed more water, but it did not keep its performance; after the first day of essay it oscillated between 1.8% and 2.5% showing that its adsorption capacity was saturated. Up to the end of the essay the water adsorption of Paints A and B, was 2.87% and 2.82% respectively. The water adsorption of paint C increased as the time elapsed reaching the value 2.2% after

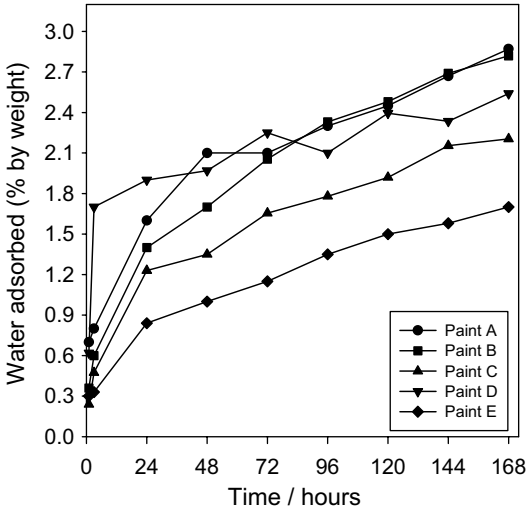

Fig. 1. Water adsorbed (% by weight) by the paints in an environment with 79.5% of humidity.

a week. All the paints with zeolitic rock behaved better than the blank (Paint E).

Paints A and B behaved better than C and D in the water adsorption test because after a fifteenth day curing process they lost all (Paint A) or almost all (98.7%, Paint B) of the water employed as solvent in the preparation. The water retention of paints C and D was 21% and 4.7% respectively for the same period, beginning the adsorption essay with an important amount of water, diminishing their water adsorption capacity during the test.

The ammonia adsorption test showed (Fig. 2) that paints B and C have the best behavior, while paint A adsorbed 8.1% at the end of the essay, being this value the lesser one. Paint D reached its saturation state after a two-day contact with the gas. From that moment up

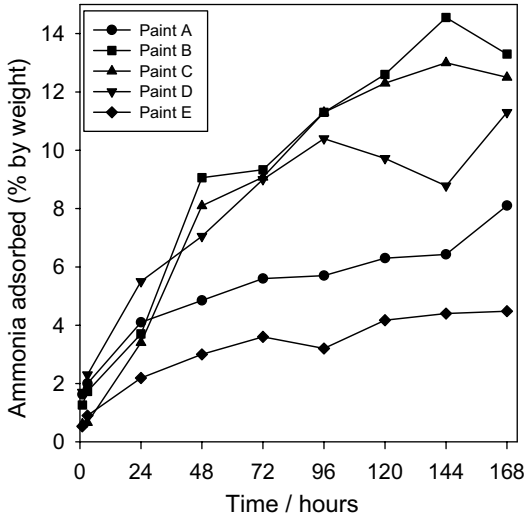

Fig. 2. Ammonia adsorbed (% by weight) by the paints in an environment saturated by the gas.

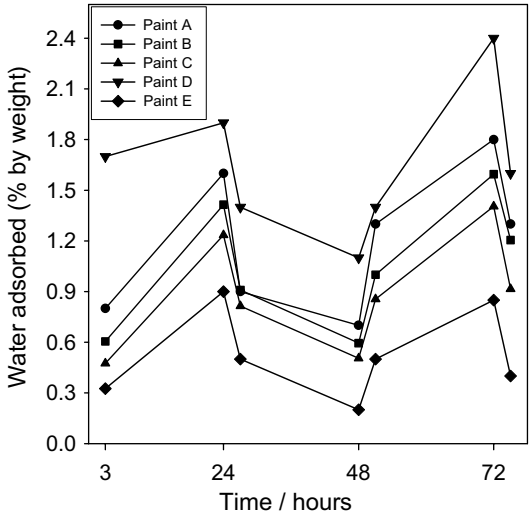

Fig. 3. Humidity adsorption–desorption cycles.

to the end of the essay, the ammonia adsorption value was around 9% while Paint E adsorption was half of this value after a seven-day contact in the chamber.

As regards to the humidity adsorption–desorption cycled test (Fig. 3) paints A, B and C, behaved in a similar way. Paints D adsorbed more water vapor during the essay but it also retained more water than the other paints when the panels were placed in the low-humidity environment (37.1%). The recovery of the adsorption capacity was near 50% after 3 h in the low humidity chamber and almost complete after 24 h. However, a little amount of water was irreversibly retained by the paints.

According to Fig. 4, during the ammonia adsorption–desorption test, paints A and D behaved in a similar way, adsorbing more than 4% of ammonia after 24 h in contact with the gas but, while paint D lost almost

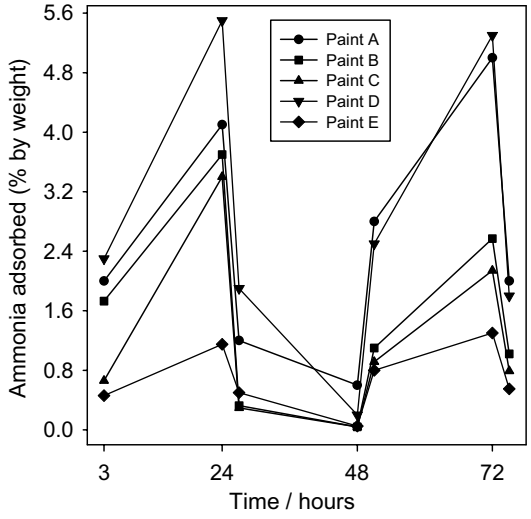

Fig. 4. Ammonia adsorption–desorption cycles.

all the gas adsorbed after 24 h of the desorption test, paint A retained 0.6% of ammonia. Paints B and C, as paint E, lost almost all the ammonia adsorbed after 24 h in the environment without the gas but, the amount of gas adsorbed was less than 3.7%. During the second adsorption–desorption cycle, only paint A adsorbed more ammonia but it also retained more gas.

6. Conclusions

- Paints with lower PVC (pigment volume concentration) behaved better than paints with higher pigment content due to the solvent retention of the latter ones during the curing period.
- Half of the adsorption capacity was recovered within three hours of the desorption test.

Acknowledgements

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