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THERMAL CHARACTERIZATION OF POLYMERIC PLASTER COMPOSITES

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Abstract

Plaster composites have been developed by the authors, aiming the manufacture of plaster boards and other building materials with enhanced properties. Polymeric plaster composites, obtained from hydration of commercial plaster of Paris with aqueous solutions of a commercial polyester, were characterized by thermogravimetry (TG) and differential thermal analysis (DTA). A method using derivative thermogravimetry (DTG) was developed to determine the polymer content in the composites and its distribution. Samples prepared conventionally by hydration of plaster of Paris with water were used as reference. Independently of the initial solution concentration, all the composites show an even distribution of the polymer, which presence enhances the composite mechanical strength.

Keywords: plaster of Paris, polymeric plaster composites, thermogravimetry

Introduction

Plaster of Paris is one of the oldest building materials manufactured in the world. Nevertheless, new plaster composites, with different kinds of fillers, are still being developed to improve their mechanical properties [1–4]. Polymeric plaster composites have been developed by the authors, aiming the manufacture of plaster boards and other building materials, with enhanced properties. Thermal analysis is usually used to characterize plaster products [5–8] as well as polymers [9]. This work presents a thermal analysis method which was developed to determine the polymer content in plaster composites, as well to study its final distribution in the composites. Some morphological aspects are presented, as well as some mechanical properties of the composites.

Experimental

Polymeric plaster composites were prepared by hydration of commercial plaster of Paris ($CaSO_4 \cdot 1/2H_2O$), with aqueous solutions of a commercial polyester. The solu-

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tion/plaster mass rate was 0.7, and solutions with three different concentrations of the polymer were used (1.25, 2.50 and 5.00 mass%). Reference samples were prepared, as well, by using water/plaster compositions with the same mass rate. All the test specimens were cast in 300 mL poly(styrene) cups, and samples taken from different parts of the resulting bodies were analyzed after being dried in an oven at 40°C, to avoid any partial decomposition of the dihydrated calcium sulphate ($CaSO_4 \cdot 2H_2O$) present in the composite after setting [10].

The analyses were performed, from room temperature to 800°C, in a simultaneous TG/DTA. T. A. Instrument, model SDT-2960, at a heating rate of 10°C min^{-1} and 100 mL min^{-1} of air, as the purge gas. The polymer content of each sample was estimated from the area of the respective DTG peak due to its burnout, which does not overlay with any other DTG peak observed in the analysis. In order to check the homogeneity of the polymer distribution, samples taken from the top, middle (bulk), bottom and from the lateral side of each composite, were analyzed. The morphology was studied by Scanning Electron Microscopy (SEM). The mean porosity and yield strength of the resulting composites were determined from 6 samples of each kind of composite.

Results and discussion

Figure 1 shows typical TG and DTG curves of the reference sample formed by hydration of the plaster of Paris with water. The first mass loss, which occurs from 90 to 180°C, is due to the structural water released from the $CaSO_4 \cdot 2H_2O$ decomposition [3]. The second one, which occurs from 580 to 700°C, is due to the decomposition of

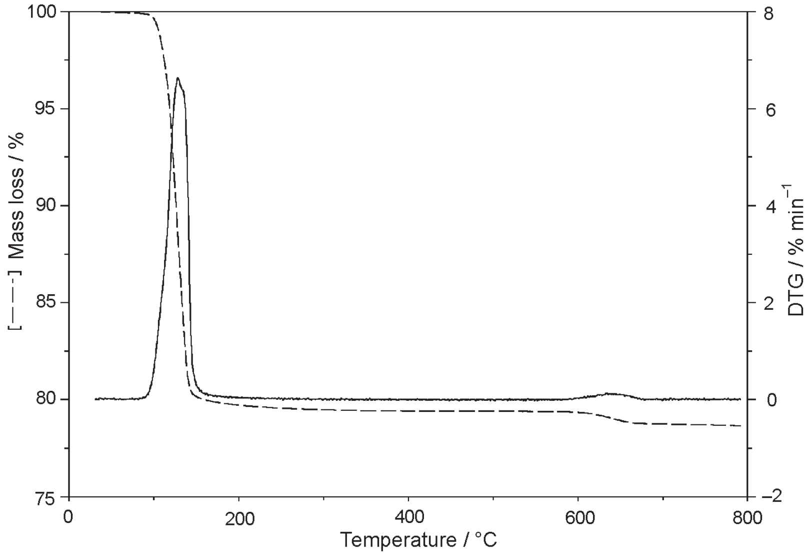

Fig. 1 TG and DTG curves of the reference sample

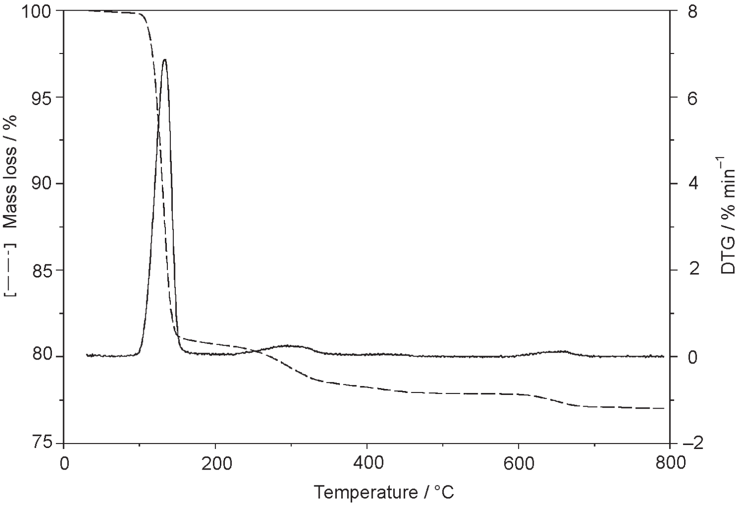

Fig. 2 TG and DTG curves of a polymeric plaster composite

some calcium carbonate ($CaCO_3$), present in the commercial plaster, which releases carbon dioxide within this temperature range [11]. Figure 2 shows typical TG and DTG curves of the composite prepared by using a 5 mass% polymer solution. As in Fig. 1, the first peak of the DTG curve is due to $CaSO_4 \cdot 2H_2O$ decomposition. The second mass loss, which occurs between 200 and 500°C, is due to the burning out of the polymer. $CaCO_3$ impurity decomposes during the third mass loss step.

Figure 3 shows the DTA curves of the previous samples. In both cases there is a first endothermic DTA peak due to $CaSO_4 \cdot 2H_2O$ dehydration. In the composite sample DTA curve there is an exothermal peak, which begins about 230 and ends by 600°C, due to the burning out of the organic polymer, which characterizes its presence [12]. The little exothermal peak between 330 and 380°C, on the DTA curve of the reference sample, is due to a crystalline transformation of the anhydrite III obtained from $CaSO_4 \cdot 2H_2O$ dehydration, to anhydrite II [7]. It may be seen that it also occurs on the DTA curve of the composite, but in a very slight way, because it is overlapped by a higher exothermal effect of the combustion of the polymer.

Figure 4 shows the DTG curves of the composite samples and of the reference sample (0% case), between 180 and 550°C. There are two main decomposition steps, as seen in DTA curves. The first begins about 200 and ends by 350°C. The second one ends by 500°C and represents the combustion of the residual carbonaceous material due to the previous polymer decomposition [13]. Figure 5 shows the distribution of the polymer content in the composites, obtained from the area of the respective DTG peaks, as a function of the polymer content in its initial aqueous solution. As may be seen, the curves show that there is a very good homogeneity of the polymer distribution, for all the cases. The mean polymer content in the composites is a linear function of the polymer content in the respective aqueous solution, with a correlation factor of 0.9962.

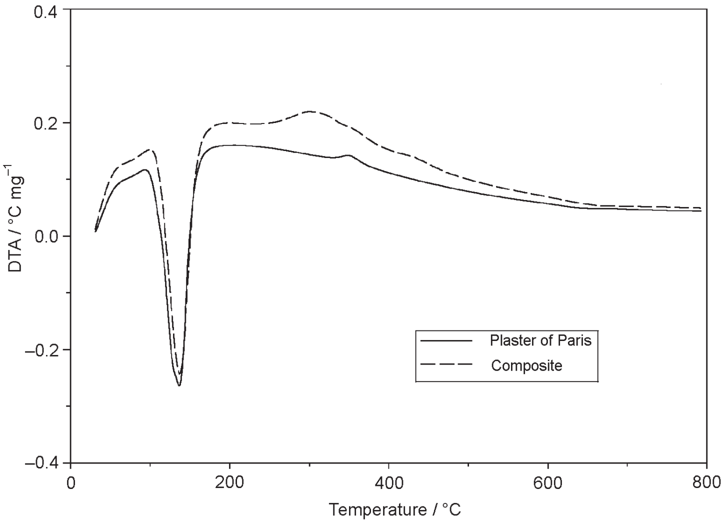

Fig. 3 DTA curves of the reference sample and polymeric plaster composite

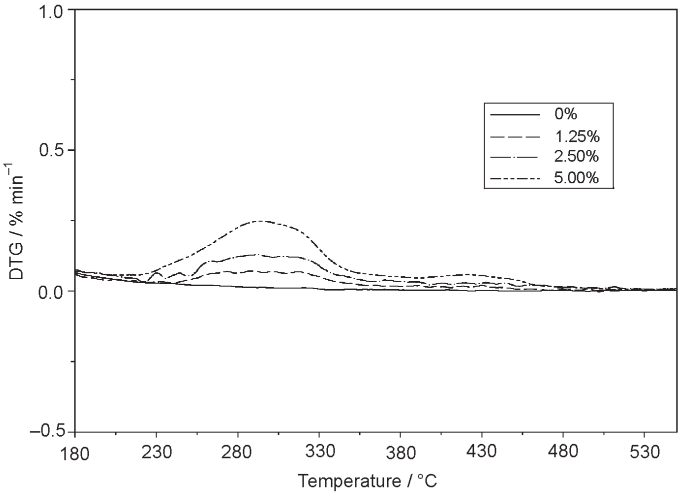

Fig. 4 DTG curves of the polymer burnout steps

Morphological aspects of the composites are shown in Fig. 6. The polymer particles are adsorpted on the needle shaped $CaSO_4 \cdot 2H_2O$ particles, which have a characteristic cubic crystalline structure. As the polymer content of the original solution increases from 1.25 to 5%, the resulting polymer content of the composites increases proportionally. As a consequence, the mean porosity of the respective composites decreases from 40.2 to 37.8%, and the mean yield strength, increases from 7.2 to 8.1 MPa. For the reference sample these properties are, respectively, 42.2% and

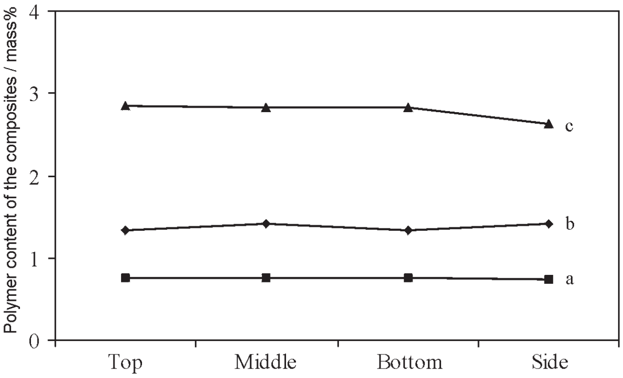

Fig. 5 Polymer distribution in the composites from different polymer concentration solutions; a – 1.25%; b – 2.5%; c – 5%

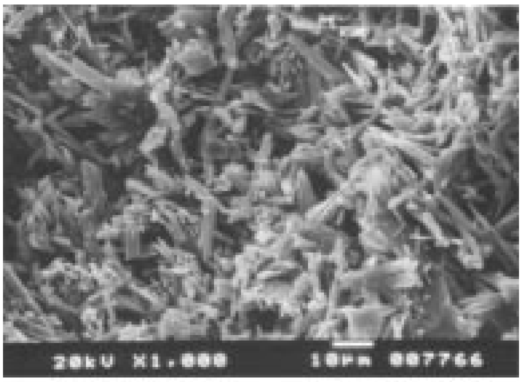

Fig. 6 Morphological aspects of the polymeric plaster composite

5.6 MPa. As can be seen, the presence of the polymer in the plaster composites enhances significantly their final mechanical properties.

Conclusions

The polymer content in plaster composites may be estimated directly from the total area of the respective DTG peaks due to its burnout in oxidative atmosphere analysis.

The composites show an even distribution of the polymer for all the cases. As the polymer content increases, the porosity of the crystalline structure of the plaster composite decreases, enhancing significantly its mechanical properties.

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