Microscopic evaluation of HDPE/gypsum composite from industrial waste

Abstract

This research intends to investigate the morphology of composites based on high density polyethylene (HDPE) and gypsum, both of them obtained from industrial waste. The HDPE was grounded in order to evaluate the influence of the particle size on the composites morphology. Two particle sizes of the HDPE were used. The components were manually mixed and processed in an injection machine, as rectangular bar, in pre-determined conditions. The specimens were observed through optical microscopy (OM) and scanning electron microscopy (SEM). The SEM showed that the particle size of the HDPE had influence on the composites morphology. The structure of the composites showed that the matrix was a mixing of HDPE and gypsum while the disperse phase was based on neat HDPE.

Keywords: Gypsum; HDPE; Recycling; Composite; OM, SEM

Introduction

Nowadays, the demands are for materials with low environmental impact, and they bring quality of life for people. The industry has searched solutions that improve innovative properties for traditional materials. An example is the gypsum, a crystalline inorganic material and constituted by many monoclinic crystals in random orientation. Although this ceramic has an apparent single elastic modulus and the individual crystals within the microstructure are anisotropic, gypsum is a material which can harden and solidifies when mixed with water, as well as it re-hydrates and hydrates. The application field is a miscellaneous in mankind history. The traditional material is a mineral, and the source of obtaining the gypsum, dehydrate calcium sulfate. When heated, gypsum turns itself into hemi-hydrate, which has wide utility in construction industry, else medical field, orthopedic and dental segments and project design. Generally, the reinforcement process includes a strengthening of the matrix and an improved load transfer upon drying, for example as the gypsum has partially filled up pores. This research has as objective to produce expanded HDPE/Gypsum composites with the purpose of thermal and acoustic insulation. Polymeric foaming is a very important and strategic low density material using as highly thermal-acoustic insulating and for absorbing shock [1-9].
Experimental

The materials used in this work were recycled gypsum - density 2.32 g/cm$^3$ and molecular weight 172g/mol - and high density polyethylene (HDPE) waste from bottles. After remaining for one hour in a Dewar full of nitrogen, the frozen HDPE was put in a knives mill and grounded in two particle sizes, 0.20 and 0.40mesh. Following, the components were mixed manually in a mortar maintaining the proportion of each component at 50 weight %.

Injection specimens were molded in rectangular bar form, at 220°C, 8 bar of pressure, during 10s of injection time, using a Ray Ran injection machine.

Optical and electron microscopies (OM and SEM) were carried out in order to evaluate the morphology of the neat materials and blends.

Results and Discussion

Figures 1-3 show the optical photographs of the recycled gypsum and HDPE and one blend of them. The recycled gypsum (Figure 1) presents itself as wet, brightness, rounded, transparent, clustering particles. The HDPE (Figure 2) shows itself as colored, shapeless, smallish scraps.

SEM photomicrographs were shown in Figures 3-7. The recycled gypsum (Figure 3) exhibits itself as laminar, agglomerated crystal particles. The composite HDPE (0.40 mesh)-Gypsum (50/50) is shown in Figure 4. The photo presents the matrix as being a mixing of polymer-gypsum bypassing a porous disperse phase. The latter was constituted by ellipsoidal, heterogeneous in size and shape porous indicating that closed cells were developed during the specimen preparation. The presence of the porous was ascribed to the remainder water in the gypsum which was released during the processing of the specimen. Inside the porous (Figure 5), only neat HDPE was noticed. Similarly, the composite HDPE (0.20 mesh)-Gypsum (50/50) Gypsum- polymer composite also exhibited a cellular structure (Figures 6 and 7). The matrix presented the same coarse texture as found in the composite with the smaller HDPE particle size. The disperse phase seems to be a little bit different from that its counterpart regarding the size and shape of the porous.
Figure 1 - Optical Microscopy – recycled gypsum crystals

Figure 2 - Optical Microscopy – scattered, recycled HDPE particles
Figure 3 - SEM of recycled gypsum

Figure 4 - SEM of recycled HDPE (0.40 mesh)-gypsum composite (x100)
Figure 5 - SEM of recycled HDPE (0.40 mesh)-gypsum composite (x1000)

Figure 6 - SEM of recycled HDPE (0.20 mesh)-gypsum composite (x500)
Conclusion

According to the SEM analysis, a cellular structure was achieved in composite of HDPE-Gypsum. A coarse matrix constituted of a mixing of the components and a disperse phase of neat HDPE were noticed. The enclosed water in the recycled gypsum played a role as a foaming agent. The HDPE particle size had influence on the composite morphologies.

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Reference: