International Journal of Biological Macromolecules 70 (2014) 381–384

Contents lists available at ScienceDirect

International Journal of Biological Macromolecules

journal homepage: www.elsevier.com/locate/ijbiomac

Improvement of reinforced concrete properties based on modified starch/polybutadiene nanocomposites

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ARTICLE INFO

Article history:
Received 9 June 2014
Received in revised form 26 June 2014
Accepted 4 July 2014
Available online 16 July 2014

Keywords:
Reinforced concrete
Carboxymethyl starch
Polybutadiene
Mechanical properties

ABSTRACT

A novel polymer-modified cement concrete with carboxymethyl starch (CMS) and 1,4-cis polybutadiene (PBD) system by mixing polymer dispersions or redispersible polymer powders with the fresh mixture have been examined. In this paper, the addition of CMS-PBD powders in an aqueous solution is studied. Polymeric molecules are supplied on a molecular scale, improving the approach of the relatively large cement grains by the polymers. The chemical and mechanical properties of CMS-PBD-modified cement concrete have been studied. The additions of very small amounts of CMS-PBD polymeric system results in an improvement of the durability and the adhesion strength of the cementitious materials, which makes them appropriate as repair materials.

1. Introduction

Polymer modification is a frequently used technique to overcome some of the shortcomings of conventional concretes such as poor tensile and impact strength, limited resistance to corrosion, poor behavior under severe conditions and poor adhesion of fresh concrete to old concrete [1]. Polymer-modified concrete are prepared by mixing a small amount of polymer with the fresh concrete mixture [2,3]. These modified concrete contain two types of binder: the system based on hydraulic cement and the polymer system. An interpenetrating network of polymer and cement hydrates is generated in which the aggregates are embedded. Polymer-modified cement concrete is produced by mixing polymer dispersions, redispersible powders, water-soluble polymers and polymeric fibers with the fresh mixture [4–8]. Even monomers can be added to the mixture on the assumption that polymerization and adequate film formation take place in combination with the cement hydration process [9]. The polymers are added to the fresh mixture as an aqueous dispersion or as a redispersible powder [10,11]. Water-soluble polymers are supplied on a molecular scale, improving the approximation of the relatively large cement grains by the polymers. In the absence of surface active agents, the film formation on the hydrate crystals will proceed more easily and uniformly and the material properties can be better tuned and modeled [12]. The various classes of water-soluble polymers are that can be used for the modification of concrete. The important class consists of modified polysaccharides such as cellulose derivates, as methylcellulose (MC) and starch derivates, carboxymethyl starch (CMS), can be added to the fresh mixture. In this paper, the use of two-components polymers in cement concrete is discussed [13,14]. The fist component of this system is the carboxymethyl starch (CMS). The second component of polymeric system is 1,4-cis polybutadiene. For many applications, it is becoming increasingly popular to reinforce the concrete with small.

Randomly distributed fibers. Their main purpose is to increase the energy absorption capacity and cracking resistance of the material. But also the increase in tensile and flexural strength is often the primary objective [15]. Fiber reinforcements increase concrete's toughness and ductility (the ability to deform plastically without fracturing) by carrying a portion of the load in the case of matrix failure and by arresting crack growth. While steel fibers are probably the most widely used and effective fibers for many applications, other types of fiber are more appropriate for special applications [16]. For example, architectural and decorative concrete products will call for fibers with a minimum of visual impact, so that nylon or polypropylene fibers may be called for. Properties of a fibrous concrete as composite material depend on properties of its components from which the major are steel or nonmetallic fibers [17]. Because the Young's modulus of steel fibers is 4–8 times that of concrete it is possible to increase strength of concrete and its crack resistance. According to lab tests, small diameter steel fibers

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http://dx.doi.org/10.1016/j.ijbiomac.2014.07.020

added to concrete mixture reduce its visible shrinkage cracking by more than 80%, increase toughness and atmospheric durability [18]. Chemical action of corrosive environments changes the structure of polymeric materials and results in irreversible deterioration of compositions. Chemical stability and water absorption of fiber reinforced concrete in acid and alkaline media are studied in the present work [19,20].

2. Materials and methods

2.1. Materials

The cornstarch was purchased from Merck Co., Germany. 1,4-PBD was prepared from our previous research project and other required materials were purchased from Sigma Chemical Co. All other solvents and materials were of analytical grade. Deionized water (Milli-Q water) was used in the preparation of buffers and standard solutions. All other chemicals and reagents used in this study were of analytical grade. Sodium hydroxide and chloroacetic acid were used as received. A grey cement PMES 42.5 according to the European standards were selected.

2.2. Instruments

Melting points were obtained on a Mel-Temp melting point apparatus. Analytical TLCs were run on commercial Merck plates coated with silica gel GF250 (0.25 mm thick). The samples were examined to determine the mean diameter and size distribution. The powder morphology nanoparticles in the form of pellets (to measure grain size) was investigated using Philips XL-30 E SEM scanning electron microscope (SEM) at 30 kV (max.). The samples were prepared by physical vapor disposition method. The gold layer thickness was about 100 Å at these samples. Mooney viscometer, Shimadzu SMV-201, was used for Mooney viscosity characterization and measurements.

2.3. Preparation of carboxymethylstarch (CMS)

Firstly, the 0.5 g corn starch and 120 ml 2-propanol were placed in a 500 ml vessel and stirred fro 2 h. The 5 g sodium hydroxide was added and reacted for 1 h at 78–80 °C. After that, the 10 g chloroacetic acid was added to the vessel and stirred for another 2 h at 50 °C. The product was filtered and washed several times with ethanol, then dried under vacuum. The resulting CMS was crushed in a mortar [degree of substitution (DS) = 0.49].

2.4. Preparation of CMS-PBD-cement concrete

Cement, CMS and PBD powders were mixed together for 2 periods of 2 min using a shaker-mixer. Unless otherwise stated, polymers matrix-to-cement ratio (P/C) was equal to 0.5–0.6% (w/w) and experiments were carried out in triplicate, also, *The CMS-PBD ratio is 0.1*. The conductivity equipment consists of a 25 °C thermostated reactor that contains 1 l of deionised water, a platinum electrode and a conductimeter. Previous to each experiment a calibration was performed with a 0.1 M KCl solution.

2.5. Scanning electron microscopy

Surface and shape characteristics of CMS-1,4-PBD-cement concrete were evaluated by means of a scanning electron microscope (FEI-Qunta-200 SEM, FEI Company, Hillsboro, OR). The samples for SEM were prepared by lightly sprinkling the samples on a bouble adhesive tape, which stuck to an aluminum stub. The stubs were than coated with gold to a thickness of ~300 Å using a sputter coater and viewed under the scanning electron microscope.

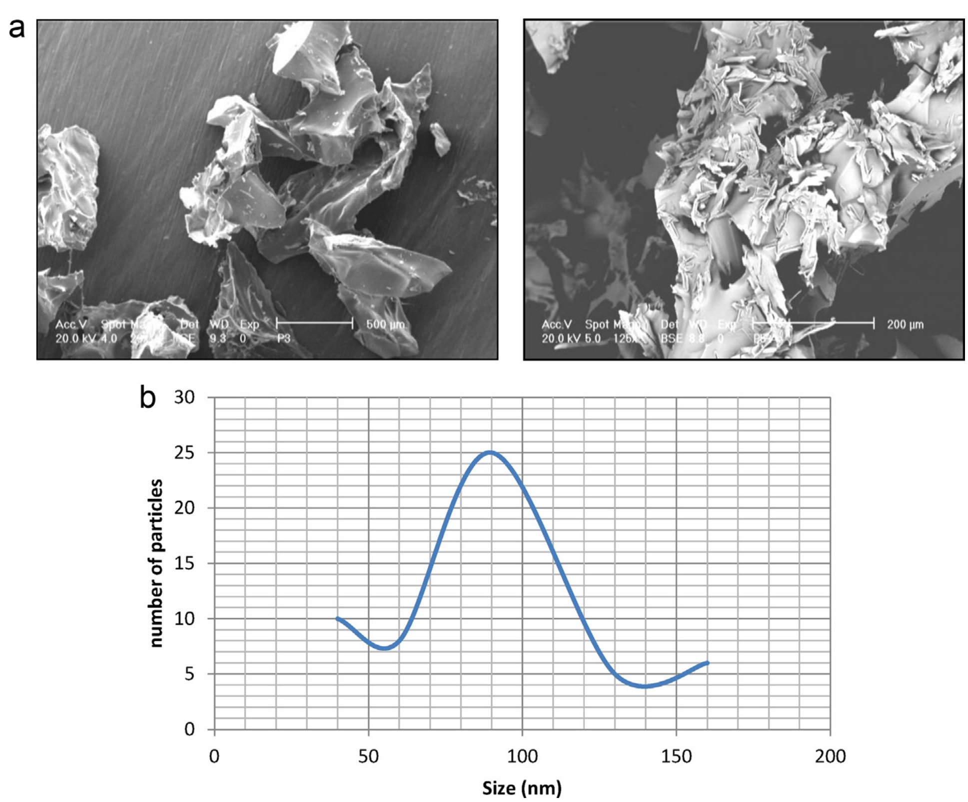

Fig. 1. (a) Morphology of CMS-PBD-modified cement concrete by emission scanning electron microscopy field. (b) The size distribution of CMS-PBD-modified cement concrete was determined from the SEM picture.