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Impact of magnesium chloride on the mechanical properties of innovative bio-mortar

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ABSTRACT

The present work aimsat studying the effect of different $MgCl_2$ concentrations on the mechanical properties of bio-mortar. Calcium/Magnesium chloride ($Ca/MgCl_2$) mixtures with molar (M) ratios of 1/0, 0.75/0.25, 0.5/0.5, 0.25/0.75 and 0/1 $Ca/MgCl_2$ were tested for their abilities to consolidate sand by mixing with 1 M urea and bacterial cells (Sporosarcina pasteurii) with 2.4 optical density at 600 nm (OD_{600}). The results showed that, the compressive strength of the prepared bio-mortar decreases with the increase of $MgCl_2$ concentration. This is mainly due to the change in the type and crystallinity of the precipitated mineral by bacterial cells within sand grains.

1. Introduction

The microbial induced calcite precipitation (MICP) has been well performed by a commonly used ureolytic *Sporosarcina pasteurii*, which previously known as Bacillus pasteurii [1–3]. This bacteria is characterized by nonpathogenic effect, urease active, aerobic and moderately alkalophilic. It has high ability to induce calcite precipitation by secration of urease enzyme, which catalyzes the degredation of urea to CO_3^{2-} and NH_4^+, resulting in the increase of the bacterial environment pH. In the presence of Ca^{2+}, the $CaCO_3$ has been precipitated [4]. The resulting precipitate is governed by four parameters: (i) Ca^{2+} concentration, (ii) CO_3^{2-} concentration, (iii) pH and (iv) availability of nucleation sites [5]. $CaCO_3$ acts as binding material to consolidate aggregates, producing what is known as bio-mortar. In general, a traditional mortar refers to a workable mixture containing cement, aggregates and water. In contrast, a bio-mortar refers to a mixture of fine sand or any other aggregates and microbially-precipitated-$CaCO_3$. The bioconsolidation process of sand grains is innovative and environmentally friendly methods [6]. The compressive strength of cementing based-mortars is so important because of it is considered the main mechanical property, which reflects most of their engineering properties.

The preparation of consolidated sand or bio-mortar using MICP phenomenon was previously carried out. Le Me´tayer-Levrel et al. [7] and Whiffin [8] applied strategy in which bacterial cells with nutrient or cementation solution (urea/$CaCl_2$) mixed together before injection into the sand, leading to immediately calcite precipitation. This method considered for coarse aggregate and rapid clogging for the voids of fine sand. Two steps injection method was done by some authors [9,10]. Parallel injection method includes the injection of bacterial cells and cementation solution at the same time [11]. Al Qabany et al. [12] and Rong et al. [13] stated that, retention periods facilitate different reactions to occur between bacterial cell and cementation solution. Shahrokhi-Shahraki et al. [14] applied one-cycle staged injection with retention periods, producing consolidated sand with unconfined compressive strength and stiffness of 50–240 kpa and 6–56 Mpa, respectively. Another method includes the injection and mixing was done by Achal et al. [1]. In this method, the bacterial cells were mixed with sterilized sand, and then growth medium containing cementation solution was injected. Indeed, the all above mentioned authors used urea-$CaCl_2$ as cementation solution. There is no any researcher studied the effect of $MgCl_2$ addition on the microbial sand consolidation. Hence, the present work aims at studying the effect

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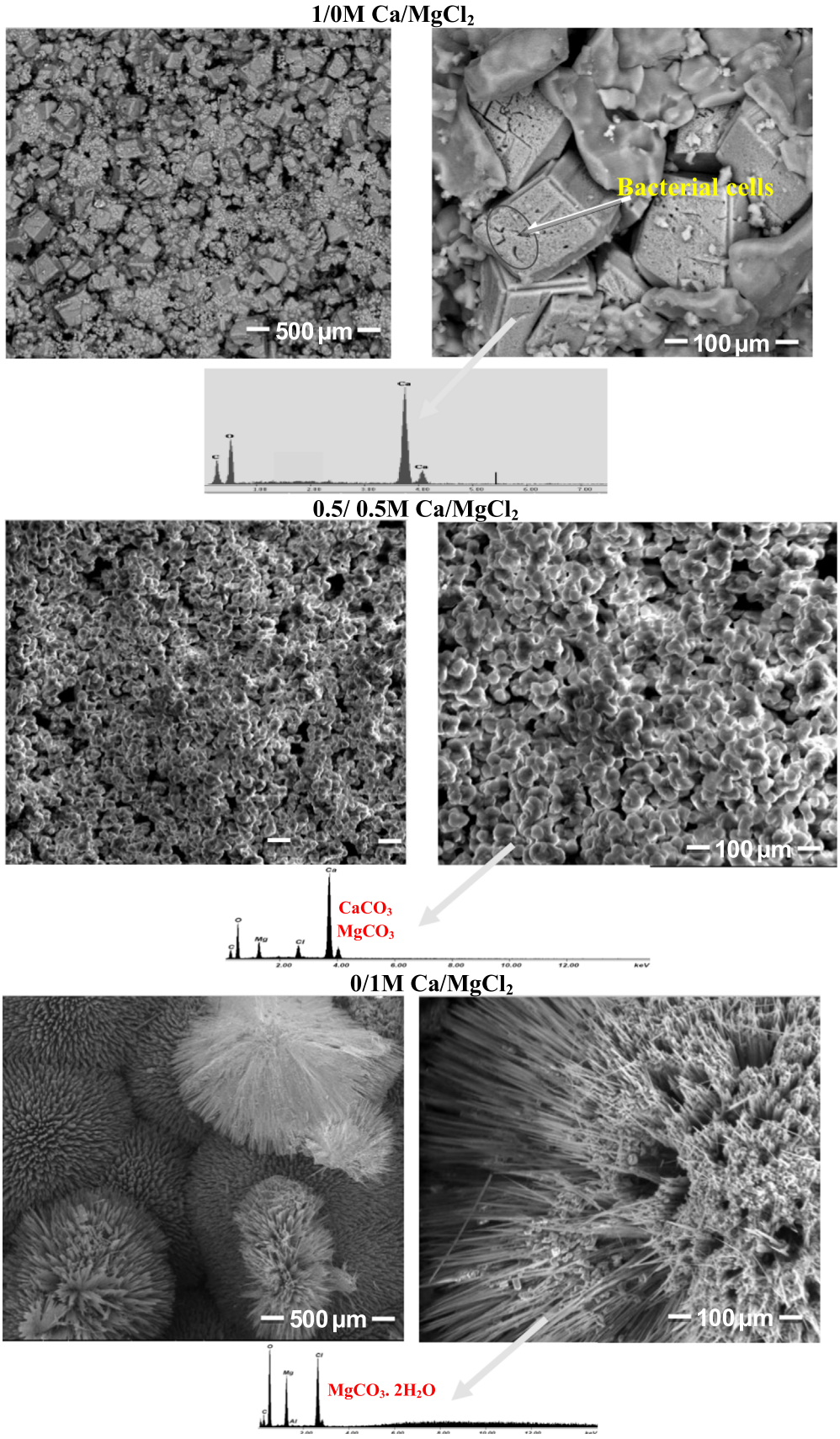

Fig. 1. SEM and EDXA of different carbonate containing phases.