Supplementary material

Article

Comparison of different magnesium hydroxide coatings applied on concrete substrates (sewer pipes) for the protection against bio-corrosion

Domna Merachtsaki[1], Eirini-Chrysanthi Tsardaka[2], Eleftherios K. Anastasiou[2], Haris Yiannoulakis[3] and Anastasios Zouboulis[1,*]

[1] Laboratory of Chemical and Environmental Technology, Department of Chemistry, Aristotle University ofThessaloniki, 54124 Thessaloniki, Greece; meradomn@chem.auth.gr
[2] Laboratory of Building Materials, Department of Civil Engineering, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece; extsardaka@gmail.com (E.-C.T.); elan@civil.auth.gr (E.A.)
[3] Research and Development Center, Grecian Magnesite S.A., 57006 Thessaloniki, Greece; h.giannoulakis@grecianmagnesite.com

*Corresponding author: zoubouli@chem.auth.gr

Text S1. Concrete specimens

In order to examine concrete substrates that resemble the corresponding concrete sewer pipes material, the reference concrete type MC(0.45) was produced, according to the EN 1766:2017 Standard [1], conforming to the requirements of the EN 1916:2002 Standard [2]. The MC (0.45) concrete type that was selected had a water/cement ratio of 0.45 and the composition of the concrete mix is presented in Table 1. Wooden molds of different dimensions (i.e. 200 mm x 200 mm x 20 mm and 50 mm x 50 mm x 20 mm), depending on each test requirements, were used for the preparation of specimens. After 24 h the concrete specimens were de-molded and cured into water for 27 days at 20±2 °C.

Table 1. The composition of concrete mixture for the production of 1 $m^3$of concrete.

Material	Type	Composition
Cement	CEM I 42.5 R	410 kg
Water	Tap water	184.5 kg
Crushed limestone sand	0-4 mm	895 kg
Crushed limestone aggregates	4-8 mm	895 kg
Plasticizer	Poly-carboxylate based	0.5% wt. solids

[1] European Committee for Standardization, EN 1766:2017 Products and systems for the protection and repair of concrete structures - Test methods - Reference concretes for testing.

[2] European Committee for Standardization, EN 1916:2002: Concrete pipes and fittings, unreinforced, steel fibre and reinforced.

Text S2. Stoichiometry calculations

The mass of coating, applied onto the concrete surface, has defined the required sprayed sulfuric acid mass for the respective stoichiometric neutralization. In order to consider the relevant calculations, the reactions of magnesium hydroxide and of calcium hydroxide (both existing in the used raw materials) with the sulfuric acid are presented in the following:

$$Mg(OH)_2 + H_2SO_4 \rightarrow MgSO_4 + 2H_2O \quad (2)$$

$$Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O \quad (3)$$

According to these reactions, one mole of magnesium hydroxide or one mole of calcium hydroxide can react with one mole of sulfuric acid. The methodology that was followed was based on the principle that the mass of each coating must be totally consumed during the tests. Based on this assumption, the respective moles of magnesium hydroxide and of calcium hydroxide contents in the coatings (expressed as oxides) were calculated. The resulting number of moles corresponds to the total number of sulfuric acid moles required to be sprayed on the coated specimens. In that way the required mass of sulfuric acid can be calculated and adjusted, according to the number of (experimental) spraying days.

Table S1. Quantitative results regarding the main mineralogical phases of the five magnesium hydroxide powders (%).

Material	Brucite $Mg(OH)_2$	Periclase MgO	Forsterite Mg_2SiO_4	Quartz SiO_2
C1	74.0	5.4	4.3	2.6
C2	75.3	5.3	4.6	2.6
C3	80.9	6.5	3.0	0.6
C4	80.7	2.4	4.2	2.2
C5	88.4	0.5	2.9	0.5

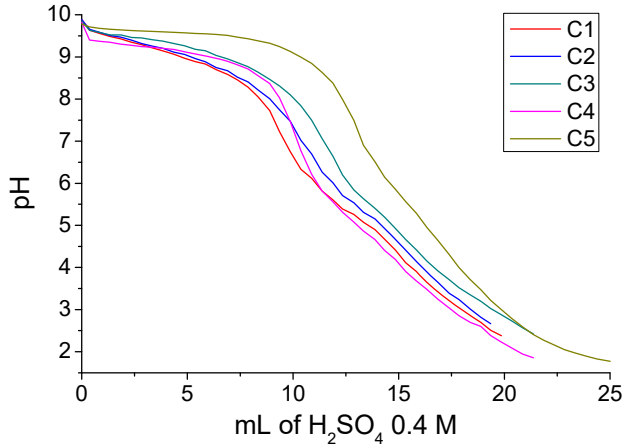

Figure S1. Maximum pH values obtained after 1 min of the addition of each drop of the sulfuric acid solution in the MH solutions. The maximum pH values obtained after 1 min of the addition of 1 drop (~0.5 mL) of sulfuric acid solution, in a dispersion of each magnesium hydroxide powder (0.5 g MH/ 100 mL of deionized water). The acid was added at the rate of one drop/min.

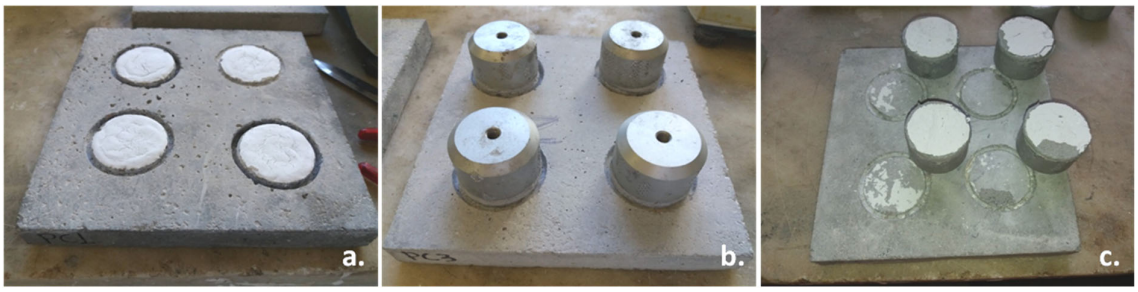

Figure S2. Steps of pull-off measurements; (a) coating applied onto the cyclical concrete surface, (b) dollies stuck onto the coating surface, and (c) dollies with coating and adhesive after the pull-off measurement.

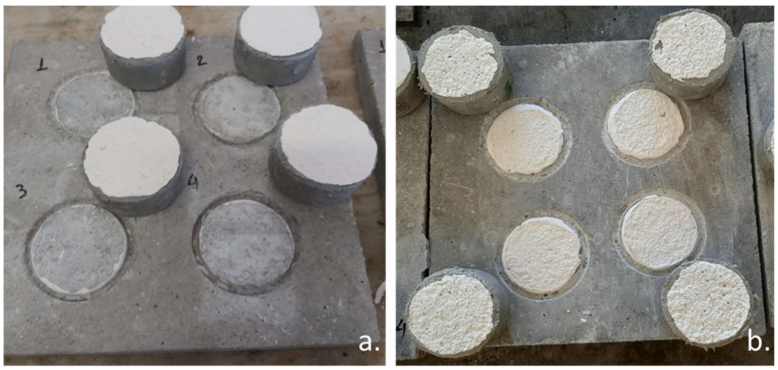

Figure S3. Type of pull-off failures (a) 100% A/B type of failure, (b) 100% B type of failure.

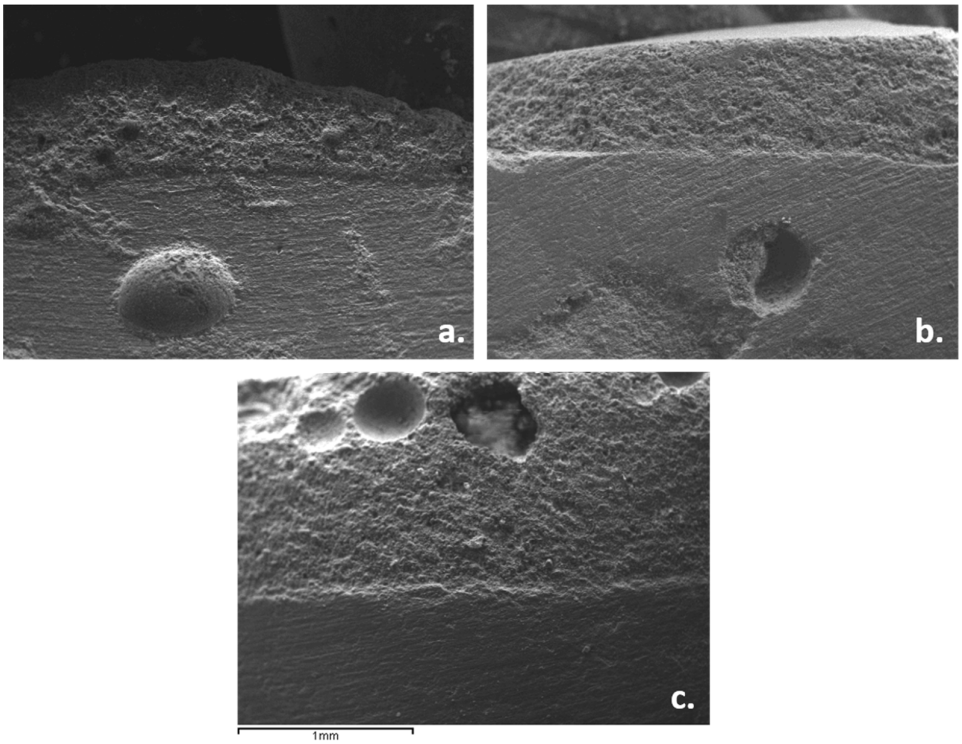

Figure S4. SEM-micrographs of the coated concrete specimens with the coatings; (a) C1, (b) C3 and (c) C5. The coatings are presented in the upper side, whereas the concrete is presented in the lower side of each image.

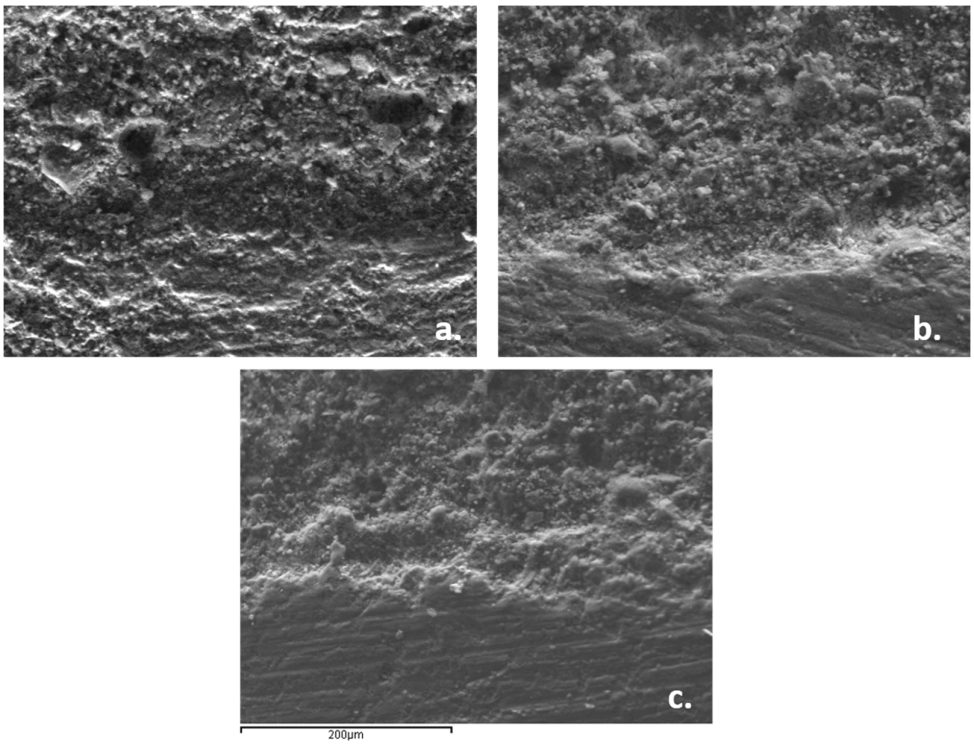

Figure S5. SEM-micrographs of the coating-concrete interfaces for the concrete specimens coated with the coatings; (a) C1, (b) C4 and (c) C5.

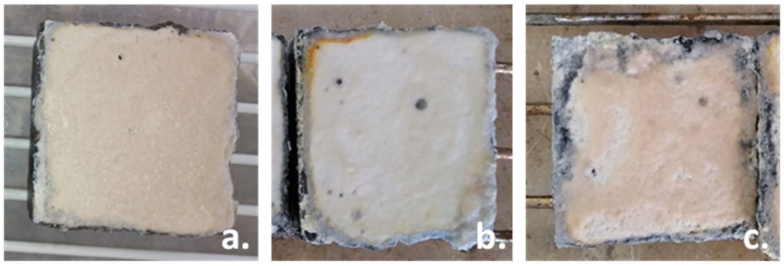

Figure S6. Coated concrete specimens with different coatings: (a) C1, (b) C3, and (c) C5, after 4 days of the 1st acid spraying test application.