The Influence of Admixed Polymeric Vesicles on Corrosion Performance of Steel in Simulated Pore Solution and/or Reinforced Mortar

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Introduction: This present study is part of a 2-years project on self-healing of corrosion damages in reinforced concrete via initially admixed nano materials with tailored properties (micelles and/or vesicles). In the previous investigation, the corrosion behavior of steel in the cement extract or reinforced mortar, in the presence of PEO₁₁₃-b-PS₇₀ micelles was studied [1-3]. In this work, the PEO₁₁₃-b-PS₇₈₀ vesicles (both with empty core and CaO core) were admixed in the simulated pore solution or reinforced mortar; the corrosion performance of the steel was investigated by the electrochemical measurements (Electrochemical impedance spectroscopy (EIS) and potentiodynamic polarization (PDP)) and surface analysis (SEM, EDX and XRD). The investigation is ongoing.

Materials and methods: The paper will discuss the influence of admixed vesicles on corrosion behavior of steel in simulated pore solution or reinforced mortar

Simulated pore solution:

Steel electrodes: Low-carbon steel 37 with surface area of 4 cm² was used. All electrodes were equally treated prior to electrochemical measurements i.e. they were grinded with no.500 to no.4000 grinding papers and rinsed with acetone just before immersing in the relevant solution.

Cement extract: The cement extract was prepared from Ordinary Portland cement CEM I 42.5 N and tap water by mixing in the weight ratio of 1:1; the suspension was filtrated after 24h rotation and thus a simulated pore solution (CE) was received. The pH of CE is 12.6-12.9.

Vesicles: Used in this study were PEO₁₁₃-b-PS₇₈₀ vesicles (both with empty core and CaO core). The vesicles in aqueous media with a concentration of 0.5 g/L (demi-water) were obtained by the dialysis method. The aqueous solution of PEO₁₁₃-b-PS₇₈₀ vesicles was added to part of the cement extracts, thus 0.0024 wt. % of the vesicles were present in chloride-free and chloride-containing cement extracts.

Reinforced mortar:

The reinforced mortar cylinders used in this present study were cast from Ordinary Portland cement OPC CEM I 42.5 N (casting according to EN 196-1), water to cement ratio (w/c) 0.5 and cement to sand ratio (c/s) 1:3. The cylinders had dimensions: H = 150 mm, D = 35 mm, containing a centrally embedded construction steel bar with exposed length of 120 mm (FeB500HKN steel rebar, d = 8 mm, used as received). For vesicles-containing specimens, the vesicles solution was used as mixing water instead of demi-water and the vesicles concentration in the reinforced mortar was 0.006 wt. % per mortar weight. After casting, the mortar cylinders were cured in a fog room (20°C, 98% relative humidity) for 28 days and further lab conditioned (2/3rd of height immersed in tap water as control condition or 5% NaCl solution as corroding condition respectively). The sample designation in this work is shown in Table 1.

Table.1 Sample designation in this study

Groups	Designation	Vesicles (Empty core)	Vesicles (CaO core)	Cl ⁻ (10g/L)
Control Groups	OPC	×	×	
	OPCV1			
	OPCV2			
Corroding Groups	OPCn	×	×	×
	OPCnV1			×
	OPCnV2			×

Results:

The results so far indicate that in simulated pore solution, the vesicles with empty core did not significantly increase the corrosion resistance of the steel; but the corrosion initiation of the steel was delayed by a very low concentration of the vesicles with CaO core in Cl-containing cement extract.

Fig.1 Morphology observation and EDX analysis of steel surface for corroding specimens (a) OPCn, (b) OPCnV1 and (c) OPCnV2

In reinforced mortar, similar effect was observed. Fig.1 shows the morphology observation and EDX analysis of the steel surface for corroding specimens at the end of the study. Corrosion products with large dimensions were observed for vesicles-free specimen. For the vesicles-containing specimens (both with empty core and CaO core), corrosion initiation was significantly delayed, evidenced by very few corrosion products on the steel surface. The chloride amount on the vesicles-containing specimens (both with empty core and CaO core) was also lower, compared to vesicles-free group. Further, the paper will discuss the correlation of electrochemical behavior and surface analysis.

[1] J. Hu, D. A. Koleva, J. H. W. de Wit, H. Kolev, K. van Breugel. *Journal of The Electrochemical Society*, 158 3 C76-C87 (2011).
[2] J. Hu, D. A. Koleva, J. H. W. de Wit, P. Petrov, K. van Breugel. *ECS Transactions*, 28 (24) 113-121 (2010).
[3] J. Hu, D.A.Koleva, K.van Breugel, J. M. C. Mol, J. H. W. de Wit. *The Influence of Admixed Micelles on Corrosion Performance of Reinforced Mortar*, the European Corrosion Congress 2010 (ERUCORR), September 13-17, 2010, Moscow, Russia.