Utility of pH-sensitive superabsorbent polymers in concrete repair

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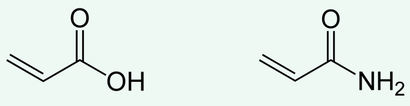
Introduction

The largest problem with concrete applications includes the occurrence of cracks due to its relatively low tensile strength. These cracks can generate an entrance for harmful particles which are dissolved in fluids and/or gases and form a threat for the durability of concrete [1]. The application of a superabsorbent polymer (SAP) in the mixing process will assist in the healing of cracks, without the use of any external factors. Novel pH-responsive SAPs will be developed and characterized for their swelling and moisture uptake capacity. Finally, the polymers will be evaluated in mortar samples and their water permeability [2] and bending and compressive strength will be assessed.

Material overview

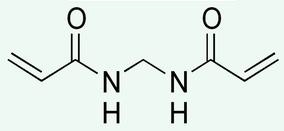
Monomers



acrylic acid (AA)

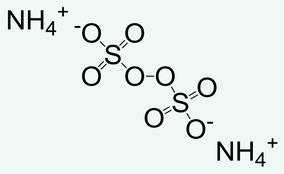
acrylamide (AM)

Crosslinker



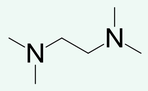
N,*N*′-methylene bisacrylamide (MBA)

Initiator



ammonium persulfate (APS)

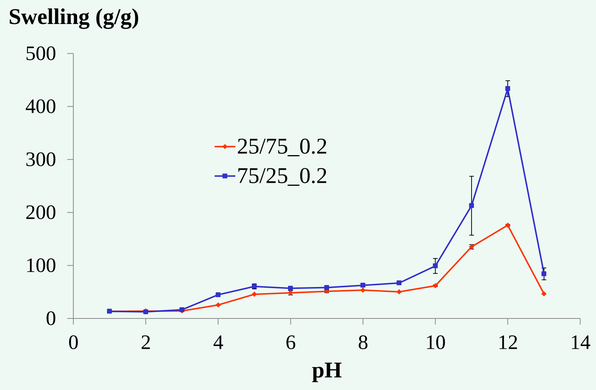
Activator



tetramethylethylenediamine (TEMED)

The materials are noted as **AA/AM_MBA**.

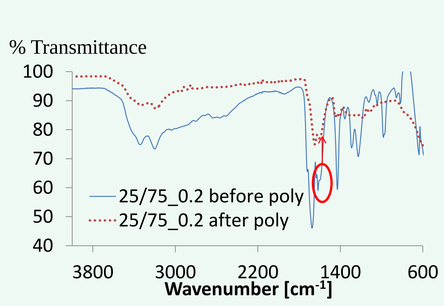
Swelling experiments

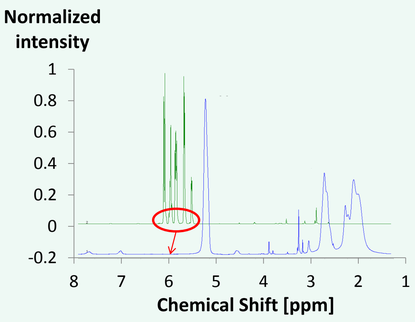


Swelling capacity of the SAP was evaluated as a function of the pH [1].

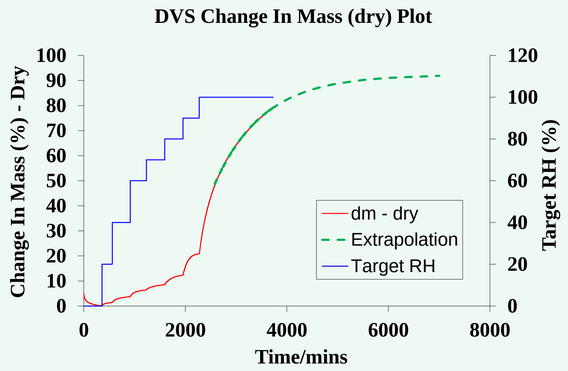
A high AA and a low MBA molar fraction resulted in the highest swelling capacity (up to 450 times its own weight at pH 12).

Characterization of the SAPs





Complementary tools (i.e. ATR-IR and HR-MAS NMR spectroscopy) illustrate the successful development of the cross-linked SAPs.

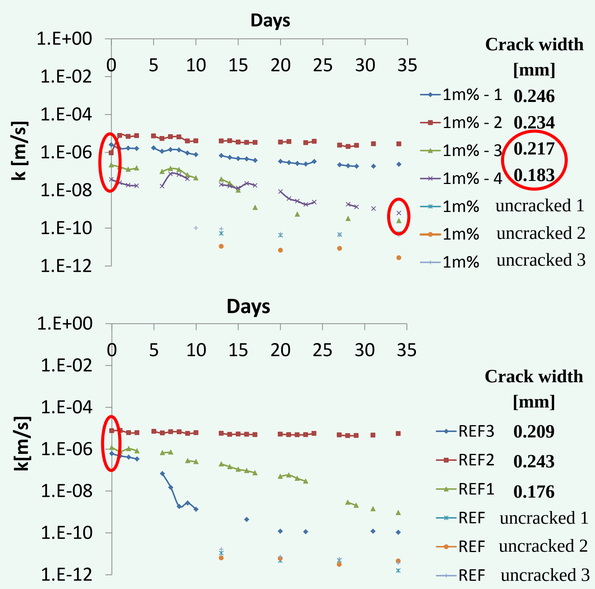


The SAPs can absorb and completely desorb more than 90% of their own weight as shown through Dynamic Vapour Sorption (DVS) measurements.

Strength + water permeability tests on mortar samples

The strength of the mortar samples decreases when additional SAP (50/50_0.2) is added.

	Bending		Compression	
	[kN]	[MPa]	[kN]	[MPa]
REF	3.9	9.3	119.3	76.5
0.5 m%	3.1	7.4	80.0	52.2
1.0 m%	2.1	5.1	57.1	37.6



The water permeability set-up (k-value) is an important test to measure the sealing capacity of cracks in concrete [2].

The superabsorbent polymer assists in sealing the crack, mainly during the first two weeks after crack initiation.

Although the strength of the mortar drops, the SAPs are fulfilling their anticipated task.

Conclusion

- The SAP developed has a swelling capacity of 450 times its own weight and a moisture uptake capacity of over 90% of its original weight.
- The strength of the mortar drops by introducing increasing SAP amounts. Therefore, additional material optimization is required (e.g. combination with natural SAPs) .
- SAPs assist in crack sealing and healing during the initial time period after crack initiation as indicated by water permeability tests.

References

[1] Snoeck, D., Van Tittelboom, K., Steuperaert, S., Dubruel, P., De Belie, N. *Self-healing cementitious materials by the combination of microfibres and superabsorbent polymers.* Journal of Intelligent Material Systems and Structures, 2012, online.

[2] Aldea C, Shah S and Karr A (1999) *Effect of cracking on water and chloride permeability of concrete. Materials in Civil Engineering* 11(3): 181–187.

Acknowledgement

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