

Vanadium leaching from thermochromic cement

Lontschar, Katrin¹; Mittermayr, Florian²; Perez, Gloria³; Dietzel, Martin¹; Galan, Isabel¹

1 Institute of Applied Geosciences, Graz University of Technology, Rechbauerstraße 12, A-8010 Graz, Austria; 2 Institute of Technology and Testing of Building Materials, University of Technology, A-8010 Graz, Austria; 3 Institute of Construction Science Eduardo Torroja, CSIC, Serrano Galvache 4, ES-28033 Madrid, Spain.

In times of global warming, the improvement of a building's energy-saving performance could be a smart way to reduce the increasing demand for resources. One possible approach is the use of thermochromic materials, which can reversibly change their optical response at a specific transition temperature. This property makes these materials very attractive for applications related to the thermal adaptation of buildings, allowing a potential use as smart regulators. Up to now, developments in this area have mainly focused on smart windows, but most recently a new approach related to the use of these materials in cement-based matrices for adaptive building envelopes has been proposed. The thermochromic properties of the materials increase solar heat absorption at cold conditions, while enhancing the rejection of solar heat to cool it during hot periods, therefore improving the building's overall energy efficiency. The use of thermochromic materials based on organic leuco dyes has proven problematic due to the degradation of the thermochromic functionality upon exposure to solar radiation. This problem can be overcome by using monoclinic vanadium dioxide (VO_2), which exhibits a reversible insulator-metal phase transition and the corresponding reflectance change in the near-infrared wavelength range. Recent results have confirmed the thermochromic behaviour of VO_2 -based mortars. However, other aspects related to the long-term stability and performance of the VO_2 -cement systems have not yet been addressed. In this study the leaching behaviour of VO_2 -cement pastes was analysed by immersing the hardened materials in water and by measuring the elemental concentrations in the leachates as a function of time by means of inductively coupled plasma optical emission spectroscopy (ICP-OES). The study was complemented with a hydration assessment conducted by isothermal calorimetry, X-ray diffraction and electron microprobe analysis. The results of the experiments demonstrate that the substitution of cement by VO_2 leads to a retardation of the hydration process. The increased solubility of vanadium in alkaline environments consequently causes the cement matrices to lose 30 % of the vanadium and even up to 85 % in powdered samples after 74 days immersed in water. Curing the samples in a carbonation chamber does not seem to provide enough protection against the problematic leaching behaviour. Further experiments need to be performed to stabilize the VO_2 particles within the matrix and obtain a more durable and efficient material.