Infrared thermography and contact angle as a tool to assess potassium nitrate crystallization

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Infrared thermography (IRT) is a non destructive and non invasive technique that detects temperature and/or emissivity parameters. In building heritage, the infrared thermography is used commonly for the detection of humidity and moisture transfer, defects or cracks as well as for the visualization of different materials and restoration phases. Last researches were focused on the study and comprehension of weathering process such as salt crystallization. Due to the fact that IRT detects temperature variations, thermodynamic processes such as crystallization (exothermic reaction) or evaporation (endothermic reaction) should be detected. The aim of this research is to study with IRT evaporation, crystallization kinetics and thermodynamics of potassium nitrate. This salt was chosen since it is commonly found in weathered parts of buildings. In addition, it has an enthalpy of more than -400 kJ/mol that could be detected by the IRT camera. An essential parameter in salt crystallisation is the nature of the substrate in contact with the solution. The specific surface or the hydrophilic / hydrophobic character of a material depends mainly on its artificial finish or on the products applied during or after restoration. For this reason, the evaporation of droplets of a potassium nitrate solution was carried out on four different substrates. The first was a black adhesive tape (3M), which served also as a reference material and was stuck to a glass slide. Its emissivity was determined to be 0.96 in the wavelength analyzed by the camera. The second was the glass slide. The third and fourth were a marble with polish and saw finish respectively. On these last three substrates, a tiny piece of 3M was stuck to serve as reference for the IRT analyses. Thanks to angle contact measurements the hydrophobic or hydrophilic character of the different substrates was quantified.

The evaporation of six droplets from a solution of KNO_3 at 80% wt saturation was recorded with passive IRT on each susbtrat. Temperature was set at 20˚C, 50ºC and 75ºC and humidity was kept constant at 35% RH. The droplets were placed on four different substrates. The image recording was carried out with a speed of 6.25 frame/second, enough to observe all the phenomena produced. In addition, the variations in the signal were recorded and graphed in several points of the droplets and compared to the black tape reference.

Droplet evaporation could be easily quantified due to the emissivity variations and the measurement in fixed points of the droplet. The heat released by phase change was not always observed. Creeping (efflorescence development) was visualized in specific points of the droplet, similarly to other salt types such as sodium chloride or sodium sulfate. A greater evaporation during efflorescence growth, involving all the already formed crystals, was observed in most of the droplets at the three temperatures, with a wicking effect recorded for the first time in this kind of process. Furthermore the spreading of the solution and further crystallization seemed to be closely related to the hydrophobic or hydrophilic character.

Keywords: infrared thermography, salt crystallization, potassium nitrate

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