Nonequilibrium synthesis of nature-inspired multicomponent iron salt

Simon E. G. Lepinay[1,*], Raymond B.T. Nijveld[2], Krassimir P. Velikov [1,3,4,*] and Noushine Shahidzadeh[1,*]
*Simon E. G. Lepinay: s.e.g.lepinay@uva.nl
1 Institute of Physics, University of Amsterdam, Science Park 904, 1098 XH, Amsterdam, Netherlands.
2 Nouryon Chemicals B.V., Zutphenseweg 10, 7418 AJ Deventer, The Netherlands
3 Unilever Innovation Centre Wageningen, Bronland 14, 6708 WH Wageningen, The Netherlands.
4 Soft Condensed Matter, Debye Institute for Nanomaterials Science, Utrecht University, Princetonplein 5, 3584 CC Utrecht, The Netherlands.

Mixed crystal engineering takes advantage of the specific properties of each component to optimize the properties of energy materials, pharmaceuticals, and food materials. Mineral compounds constitute a rich and inspiring database from which new functional materials can be designed. D'ansite-(Fe): known as $Na_{21}Fe(SO_4)_{10}Cl_3$ is a multicomponent mineral which was only recently discovered in volcanic fumaroles in Italy in 2011[1]. However, the synthesis and crystal growth of such multicomponent double salts at high temperature is challenging as iron oxidizes and/or hydrolyzes readily in such conditions. We report on the first synthesis of D'ansite-Fe at ambient temperature using an antisolvent precipitation strategy. We show that this double salt leads to improved stability to oxidation while still being highly water-soluble compared to its single components. Different analytical techniques such as Raman confocal microscopy, X-ray diffraction and ICP-OES are used to quantify the precipitated crystals, their morphology, and their composition. The ability to crystallize this rare multicomponent mineral at the laboratory scale opens new routes for its potential applications such as food delivery system for Iron to combat anemia [2]. Another important potential application be its great potential as new alternative and cost-efficient insertion sulfate-based material for Na-ion batteries [3].

References:

[1] Demartin F et al. D'ansite-(Mn), $Na_{21}Mn^{2+}(SO4)_{10}Cl_3$ and d'ansite-(Fe), $Na_{21}Fe^{2+}(SO4)_{10}Cl_3$, two new minerals from volcanic fumaroles. *Mineralogical Magazine*, 2012;76(7):2773-2783.
[2] Hurell RH Iron Fortification Practices and Implications for Iron Addition to Salt. *The Journal of Nutrition*, 2021; 151(1):3-14.
[3] Goikolea et al. Na-ion batteries—approaching old and new challenges. *Advanced Energy Materials*, 2020; 10, (44):2002055.