GRAPHENE AND 2DM VIRTUAL CONFERENCE & EXPO
10 ANNIVERSARY
Graphene online 2020
October 19-23

Processing of Layered Double Hydroxides for Energy Applications

Marco Piccinni[1,2], Sebastiano Bellani[2,3], Gabriele Bianca[1,2], Francesco Bonaccorso[2,3]

[1]Dipartimento di Chimica e Chimica Industriale, Università degli Studi di Genova, via Dodecaneso 31, 16146 Genoa, Italy . [2]Istituto Italiano di Tecnologia, via Morego 30, Genoa, Italy. [3]BeDimensional Spa., via Albisola 121, 16163 Genova, Italy.

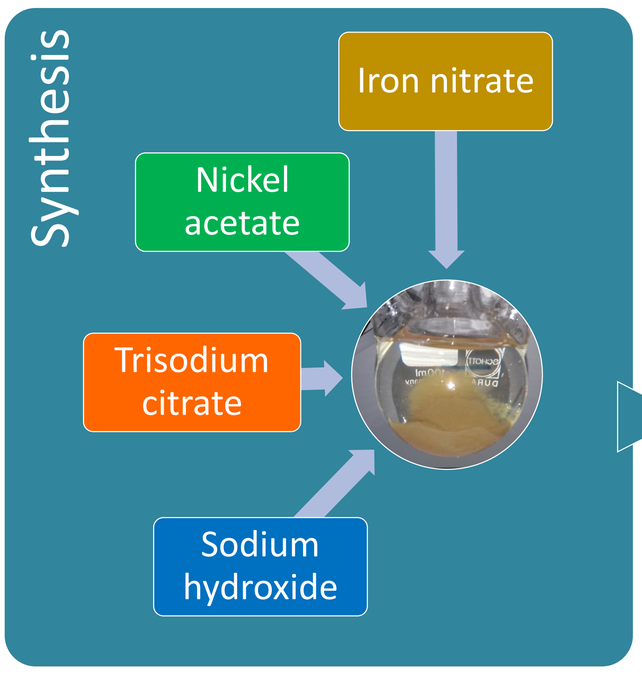
ISTITUTO ITALIANO DI TECNOLOGIA

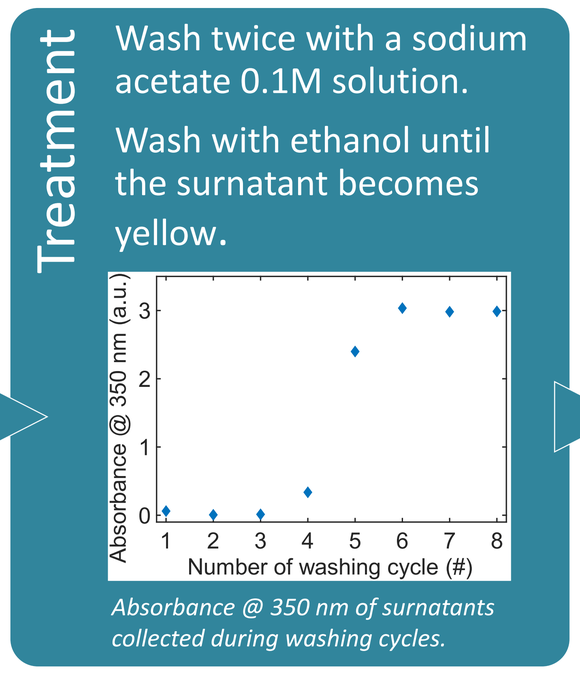
Università di Genova

Introduction

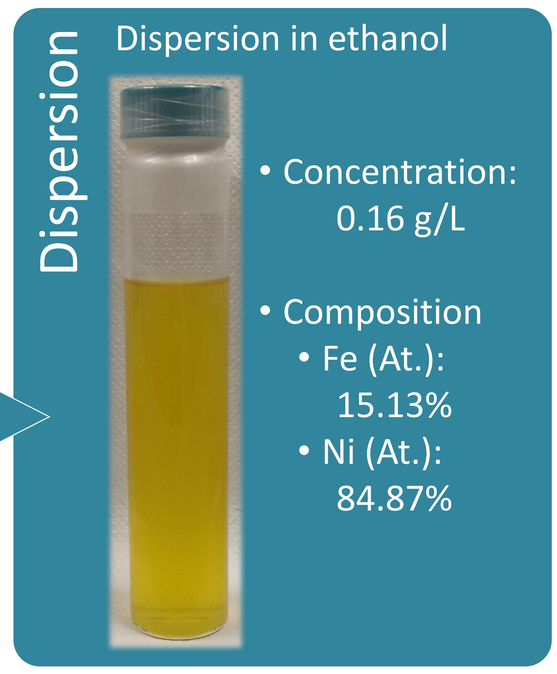
Layered double hydroxides (LDHs) are a class of anionic clays consisting of positive charged brucite-like layers spaced by water molecules and counterbalancing anions[1]. In particular, transition metals LDHs have drawn attention for energy storage and conversion applications[2] because of their electrocatalytic and photocatalytic properties[3][4]. Contrarily to other layered materials, LDH layers are held together by electrostatic forces and a dense network of hydrogen bonds[1]. For these reasons, a careful choice of solvent is pivotal for an efficient exfoliation of the LDHs. One of the most effective solvent is formamide[5]. However, due to formamide toxicity and its high boiling temperature, other solvents are recommended for the processing of LDHs[6]. In our work, we report that the presence of both acetate and citrate anions during the synthesis of nickel-iron layered double hydroxide (NiFe-LDH) makes possible its exfoliation during the dispersion in ethanol.

Synthesis and chemical exfoliation

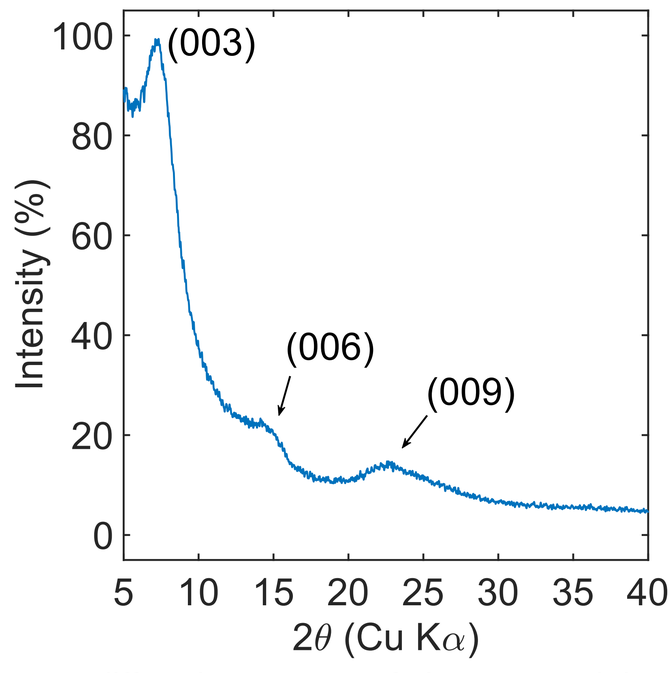




Absorbance @ 350 nm of surnatants collected during washing cycles.



X-ray diffraction



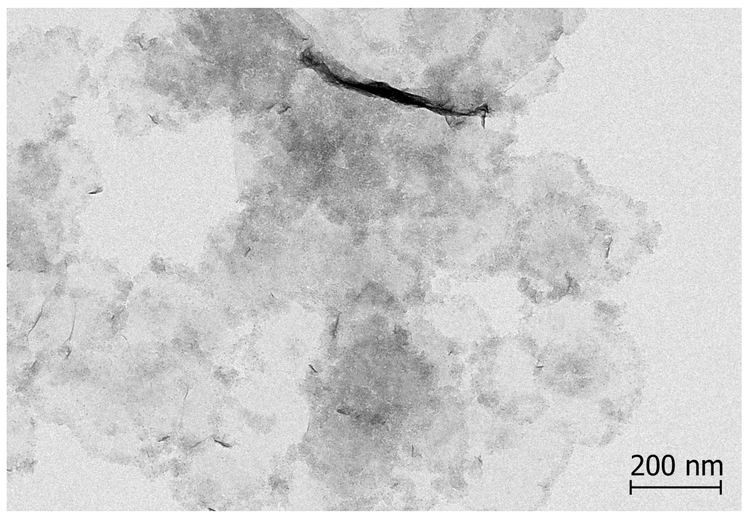
X-ray diffraction pattern of citrate containing NiFe-LDH dispersion drop-casted on Si(100).

The presence of only (00l) broad reflections is indicative of the restacking onto the Si(100) surface of previously dispersed nanosheets[7]. Moreover the lattice parameter d(003) correspond to the thickness of a single LDH layer[1].

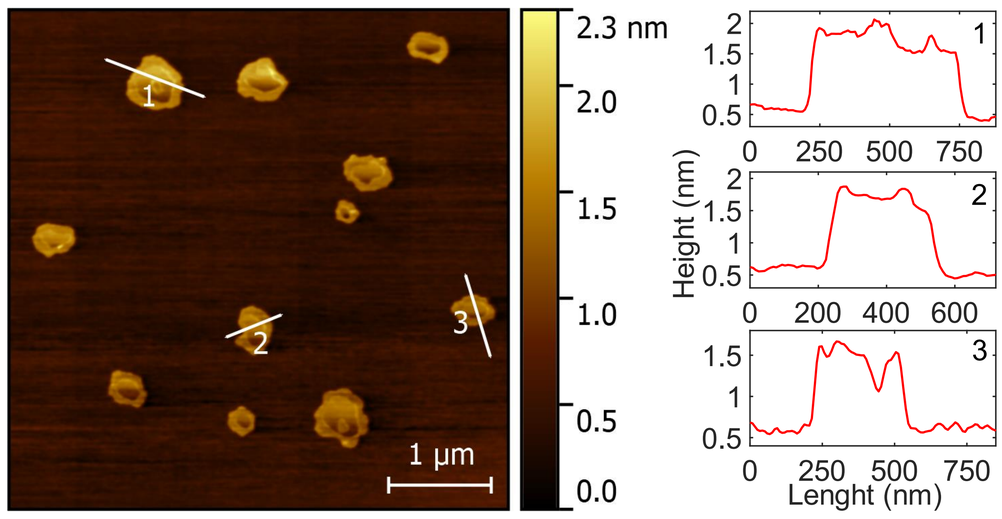
Lattice parameters (nm)	
d(003)	1.22
d(006)	0.61
d(009)	0.39

Lattice parameters calculated from the X-ray diffraction pattern via the Bragg's equation.

Microscopies

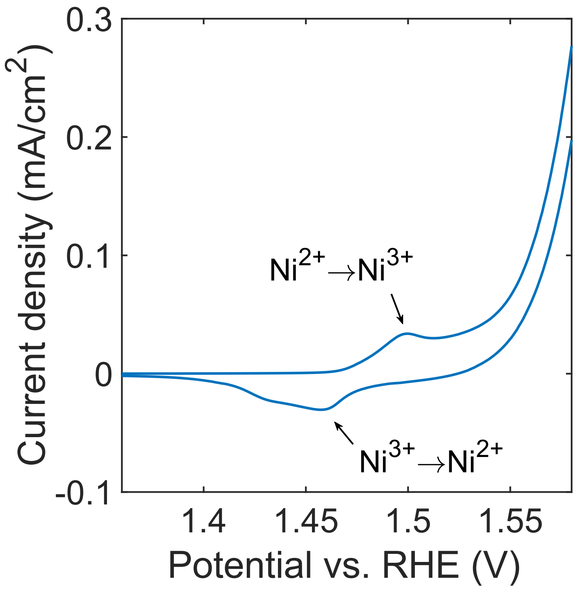


Transmission electron microscopy image of citrate containing NiFe-LDH nanosheets.

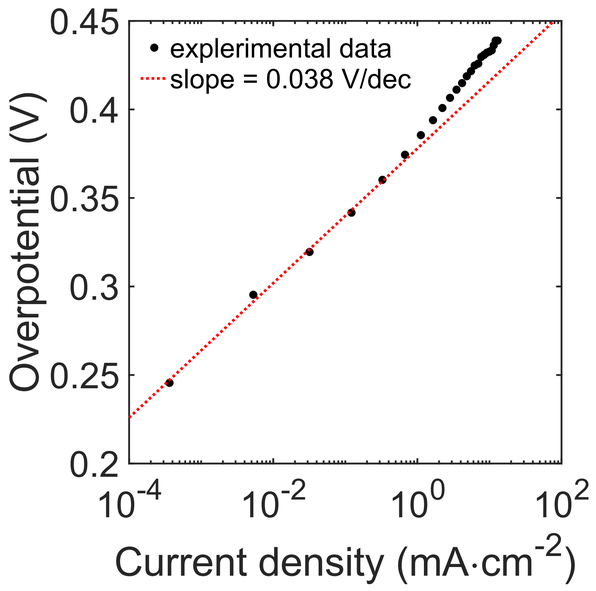


Atomic force microscopy image and height profiles of NiFe-LDH nanosheets deposited on mica.

Electrochemistry



Cyclic voltammetry of NiFe-LDH showing the characteristic redox peaks of nickel based hydroxides.



Polarization curve obtained by staircase voltammetry of NiFe-LDH. The overpotential is referred to OER.

The polarization curve of NiFe-LDH nanosheets deposited on carbon paper shows an electrocatalytic activity for the oxygen evolution reaction (OER). We measured an overpotential of 0.43 V @ 10 mA/cm^2 current density with a mass loading 0.1 mg/cm^2. Moreover, a Tafel slope of 38 mV/dec is retained for current densities up to10 mA/cm^2.

Conclusions

The combined presence of acetate and citrate anions inside the reaction mixture produces nickel-iron layered double hydroxides (NiFe-LDH) that are exfoliated into single-layer nanosheets during their dispersion in ethanol. The formation of single-layer nanosheets is confirmed by X-ray diffraction and atomic force microscopy analyses. Lastly, the investigation of NiFe-LDH as electrocatalyst for the OER is promising for practical applications.

CONTACT PERSON

- Marco Piccinni
marco.piccinni@iit.it
- Sebastiano Bellani
s.bellani@bedimensional.it
- Francesco Bonaccorso
f.bonaccorso@bedimensional.it

REFERENCES

[1] F. Cavani et al., Catalysis Today, 1991, 11, 2, 173-301.
[2] H. Koshikawa et al., ACS Catal. 2020, 10, 3, 1886-1893.
[3] M. Gong et al., J. Am. Chem. Soc. 2013, 135, 23, 8452-8455.
[4] L. Mohapatra and K. Parida, J. Mater. Chem. A, 2016, 4, 10744-10766.
[5] T. Hibino and W. Jones, J. Mater. Chem., 2001, 11, 1321-1323.
[6] Q. Wang and O'Hare, Chem. Rev. 2012, 112, 4124-4155
[7] C.F. Holder and R.E. Shaak, ACS Nano, 2019, 13, 7, 7359-7365.

Graphene online 2020