Prussian Blue Analogues of Reduced Dimensionality

Gengler, Regis Y. N.; Toma, Luminita M.; Pardo, Emilio; Lloret, Francesc; Ke, Xiaoxing; Van Tendeloo, Gustaaf; Gournis, Dimitrios; Rudolf, Petra

Published in:
Small

DOI:
10.1002/smll.201200517

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2012

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):

Copyright
Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license. More information can be found on the University of Groningen website: https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment.

Take-down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): http://www.rug.nl/research/portal. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

Download date: 20-05-2022
Supporting Information

for Small, DOI: 10.1002/smll.201200517

Prussian Blue Analogues of Reduced Dimensionality

Régis Y. N. Gengler, Luminita M. Toma, Emilio Pardo, Francesc Lloret,* Xiaoxing Ke, Gustaaf Van Tendeloo, Dimitrios Gournis,* and Petra Rudolf*
Prussian Blue Analogues of Reduced Dimensionality**

Régis Y.N. Gengler, a Luminita M. Toma, a Emilio Pardo, b Francesc Lloret, b Xiaoxing Ke, c Gustaaf Van Tendeloo, Dimitrios Gournis d and Petra Rudolf a

Dr. R.Y.N. Gengler, Dr. L. M. Toma, Prof. P. Rudolf
a Zernike Institute for Advanced Materials, University of Groningen, Nijenborgh 4, NL-9747AG Groningen, The Netherlands. E-mail: p.rudolf@rug.nl
Dr. E. Pardo, Prof. F. Lloret
b Instituto de Ciencia Molecular (ICMol)/Departament de Química Inorgànica, Universitat de València, Edificios Institutos de Paterna, Catedrático José Beltrán Martínez nº 2, 46980 Paterna, Spain. E-mail: francisco.lloret@uv.es
c Dr. Xiaoxing Ke, Prof. Gustaaf Van Tendeloo
EMAT research group, University of Antwerp, Groenenborgerlaan 171, B-2020 Antwerpen Belgium
Prof. D. Gournis
d Department of Materials Science and Engineering, University of Ioannina, GR-45110 Ioannina, Greece. Email: dgourni@uoi.gr

Supporting information.

Plots of ln τ versus 1/T
As described in the main text, we found a frequency-dependence of the χ’ and χ” components in ac measurements in the 1-1000 Hz range for 120-layer hybrid films of DODA-clay-CsNiCr, DODA-clay-CsMnCr and DODA-clay-CsNiMnCr, which indicates a slow magnetic relaxation of the magnetization. The temperature dependence of the associated relaxation time of the magnetization, τ, is plotted in Figure S1 for DODA-clay-CsNiCr, DODA-clay-CsMnCr. These graphs can be well approximated by a purely linear fit, meaning that the behaviour follows an Arrhenius law. The fits give unphysical values for τ₀ (~10⁻²⁰ s for CsNiCr and ~10⁻²² s for CsMnCr), well above typical relaxation values of ~10⁻⁹ to 10⁻¹² s for superparamagnets. These very low and unphysical values of τ₀ suggest that not only one energy barrier exists but a large number of them and therefore disordered ferro- (CsNiCr) and

![Graph showing ln τ versus 1/T](image-url)
ferrimagnets (CsMnCr) occur in the films. In fact, very low values for $\tau_0$ are obtained ($\tau_0 \approx 10^{-30} - 10^{-40}$ s) when applied to spin glasses.[1][2]

**Energy dispersive X-ray spectroscopy (performed in the transmission electron microscope)**

![EDX spectrum](image)

**Figure S2** STEM-EDX spectrum of from a thin lamella prepared from a 120-layer hybrid films of DODA-clay-CsNiMnCr deposited on mylar. Ga is present due to FIB milling using Ga ions. This spectrum is in perfect agreement with the X-ray photoelectron spectroscopy data discussed in the main text.

**X-ray diffraction**

To rule out the presence of Prussian Blue analogue nano or micro crystallites, we performed XRD for wider angles (above 10°) on a 120-layer hybrid films of DODA-clay-CsMnCr deposited on mylar; the result is shown in figure S3. This angular range should bear the ‘signature’ of PBA crystalline diffraction peaks if crystallites were present [3][4]. However, characteristic PBA peaks expected for 2θ between 10 and 20° are not observed. This testifies once more to the presence of a bidimensional PBA layer. The peak observed for 2θ between 23 and 28° is due to the substrate as confirmed by the XR diffractogram of mylar alone (blue curve).
Figure S3. XRD of a 120-layer hybrid film of DODA-clay-CsNiMnCr deposited on mylar for wider angular range. The corresponding diffractogram of the substrate alone is shown for comparison. The top curve was offset for readability. The peaks observed between 23 and 28° stem from mylar.