

University of Groningen

Multifunctional organic-inorganic hybrid films deposited by the Langmuir-Blodgett technique

Akhtar, Naureen

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:
2013

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):
Akhtar, N. (2013). *Multifunctional organic-inorganic hybrid films deposited by the Langmuir-Blodgett technique*. s.n.

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.

***Multifunctional Organic-Inorganic Hybrid
Films Deposited by the Langmuir-Blodgett
Technique***

Naureen Akhtar



**rijksuniversiteit
 groningen**

This work was performed within “Top Research School” program of the Zernike Institute for Advanced Materials under the Bonus Incentive Scheme (BIS) of the Netherlands’ Ministry of Education, Science, and Culture and received additional support from the 'Stichting voor Fundamenteel Onderzoek der Materie (FOM)', which is financially supported by the 'Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO)'.

Front Cover: An artistic view, designed by Naureen Akhtar, representing the flexible layered structure, where individual functional layers are stacked to give multifunctionality in a single material.

Printed by: Ipskamp Drukkers B.V.

ISBN: 978-90-367-6105-5 (printed version)

ISBN: 978-90-367-6104-8 (electronic version)

ISSN: 1570-1530

Zernike Institute for Advanced Materials PhD-thesis series 2013-07

RIJKSUNIVERSITEIT GRONINGEN

Multifunctional Organic-Inorganic Hybrid Films Deposited by the Langmuir-Blodgett Technique

Proefschrift

ter verkrijging van het doctoraat in de
Wiskunde en Natuurwetenschappen
aan de Rijksuniversiteit Groningen
op gezag van de
Rector Magnificus, dr. E. Sterken,
in het openbaar te verdedigen op
vrijdag 19 april 2013
om 16:15 uur

door

Naureen Akhtar

geboren op 29 maart 1985
te Rawalpindi, Pakistan

Promotor:

Prof. dr. P. Rudolf

Beoordelingscommissie:

Prof. dr. G. Van Tendeloo

Prof. dr. V. Marvaud

Prof. dr. T.T.M. Palstra

Table of Contents

Chapter 1: Introduction	8
1.1. Hybrids: A land of multidisciplinary	9
1.2. Motivation	10
References	12
Chapter 2: Experimental Details	14
2.1. The Langmuir-Blodgett technique	15
2.1.1. The surfactant monolayer at the air/water Interface – Langmuir film	15
2.1.2. Surface pressure	17
2.1.3. Surface pressure-area isotherm	19
2.1.4. Deposition – formation of the Langmuir-Blodgett film	21
2.1.5. Practical aspects	23
2.1.6. Preparation of the substrates	24
2.2. Characterization techniques	24
2.2.1. Brewster angle microscopy (BAM)	25
2.2.2. X-ray photoelectron spectroscopy (XPS)	26
2.2.3. X-ray diffraction (XRD)	28
2.2.4. Transmission electron microscopy (TEM)	30
2.2.5. Infrared spectroscopy (IR)	31
2.2.6. Electrical transport measurements	31
2.2.7. Magnetic characterization	32
References	32
Chapter 3: Introduction to Molecule-Based Conducting and Magnetic Langmuir-Blodgett Films	34
3.1. Introduction	35
3.2. Molecule-based conducting Langmuir-Blodgett films	35
3.2.1. TCNQ-based conducting Langmuir-Blodgett films	36
3.2.2. Phthalocyanines-based conducting Langmuir-Blodgett films	37
3.2.3. TTF-based conducting Langmuir-Blodgett films	38
3.3. Magnetic Langmuir-Blodgett films	41
3.3.1. Metal cyanide networks – 2D analogues of Prussian Blue	42
3.3.2. Polyoxometalate complexes	46
3.3.3. Single-molecule nanomagnets	46
3.3.4. Magnetic nanocrystals	48
3.4. Langmuir-Blodgett films with mixed functionalities	48
3.5. Concluding remarks	50
References	51

Chapter 4: Structure and Electrical Conductivity of Hybrid Langmuir-Blodgett Films from BEDO-TTF and Fatty Acid.....55

4.1. Introduction.....	56
4.2. LB film preparation.....	57
4.3. Results and discussion.....	58
4.3.1. π -a isotherms.....	58
4.3.2. XRD patterns.....	60
4.3.3. Fourier transform IR spectroscopy.....	63
4.3.4. DC sheet resistance of the LB films.....	65
4.4. Summary.....	67
References.....	68

Chapter 5: Design of Molecule-Based Magnetic Conductors.....70

5.1. Introduction.....	71
5.2. LB film deposition.....	72
5.3. Results and discussion.....	72
5.3.1. π -a isotherm study of the Langmuir films.....	72
5.3.2. X-ray photoelectron spectroscopy analysis of the multilayer LB films.....	76
5.3.3. Fourier transform IR spectroscopy.....	81
5.3.4. Structural analysis by X-ray diffraction.....	82
5.3.5. Transmission electron microscopy investigations.....	86
5.4. Conclusion.....	88
References.....	88

Chapter 6: Ultrathin Molecule-Based Magnetic Conductors91

6.1. Introduction.....	92
6.2. Results and discussion.....	93
6.2.1. DC electrical transport properties.....	93
6.2.2. Optical conductivity.....	95
6.2.3. Magnetic properties.....	98
6.3. Conclusion.....	102
References.....	103

Appendix: Transmittance of an absorbing thin film on a transparent substrate including an infinite amount of multiple reflections within the film.....106

Chapter 7: Thin Film Deposition of Perovskite-Based Ferromagnetic Organic-Inorganic Hybrid.....110

7.1. Introduction.....	111
------------------------	-----

7.2.	LB film preparation.....	112
7.3.	Results and discussion.....	112
7.3.1.	Characterization of the Langmuir film and deposition.....	112
7.3.2.	Scanning electron microscopy (SEM).....	116
7.3.3.	X-ray photoelectron spectroscopy data acquisition and analysis	117
7.3.4.	X-ray diffraction analysis of multilayer LB films	121
7.3.5.	Magnetic characterization	124
7.4.	Conclusion and perspectives	126
	References.....	127
	Summary.....	129
	Samenvatting	131
	Acknowledgment	133