-Chief

Prof. Dr. Sci. Tran Van

Deputy Editor in Chief Prof. Dr. Sci. Tran Vinh

Dieu

Editorial Board	
Prof. Dr. Nguyen Viet Bac	Millitary Institute of Chemistry and Material, Hanoi, Vietnam
Assoc. Prof. Dr. Pham Van Cuong	Institute of Marine Biochemistry, VAST
Assoc. Prof. Luu Minh Dai	Institute of Material Science, VAST
Prof. Dr. Sci. Trinh Xuan Gian	Institute of Chemistry, VAST
Prof. Dr. Le Xuan Hien	Institute for Tropical Technology, VAST
Assoc. Prof. Dr. Vu Dinh Hoang	Hanoi University of Science and Technology
Prof. Dr. Sci. Nguyen Duc Hung	Millitary Institute of Chemistry and Material, Hanoi, Vietnam
Prof. Dr. Le Quoc Hung	Institute of Chemistry, VAST
Prof. Dr. Nguyen Cuu Khoa	Institute of Applied Materials Science, VAST
Prof. Dr. Nguyen Van Khoi	Institute of Chemistry, VAST
Assoc. Prof. Dr. Phan Van Kiem	Vietnam Academy of Science and Technology
Prof. Dr. Sci. Luu Cam Loc	Institute of Chemical Technology, VAST
Prof. Acad. Chau Van Minh	Vietnam Academy of Science and Technology
Prof. Acad. Dang Vu Minh	Vietnam Union of Science and Technology
Prof. Dr. Nguyen Kim Phi Phung	Ho Chi Minh City University of Sciences, HCM VNU
Assoc. Prof. Dr. Duong Tuan Quang	Hue University of Education, Hue University
Prof. Dr. Sci. Phan Tong Son	Hanoi University of Science, VNU
Prof. Dr. Sci. Dang Nhu Tai	Hanoi University of Science, VNU
Prof. Dr. Sci. Ngo Thi Thuan	Hanoi University of Science, VNU
Assoc. Prof. Dr. Vu Quoc Trung	Hanoi National University of Education
Prof. Dr. Nguyen Van Tuyen	Institute of Chemistry, VAST
Prof. Dr. Sci. Dang Ung Van	Hoa Binh University
Prof. Dr. Peter Langer	University of Rostock, Institute of Chemistry, Germany
Prof. Dr. Young Ho Kim	Department of Natural Product Chemistry College of Pharmacy, Chungnam National University, Korea
Prof. Dr. Kotohiro Nomura	Tokyo Metropolitan University, Japan
Prof. Dr. Toru Fujii	Doshisa University, Kyoto, Japan
Prof. Dr. Nguyen Minh Tho	Department of Chemistry University of Leuven, Belgium

NSTRUCTIONS FOR AUTHORS

acy, pharn on in Vieti experiment urnal of Che ws, and letter ental and gg namese or English. T al and +^{1.} logy, and hemistry put ers in all are res publishes research areas of chemistry, stry, environmental resource, medicine, xy nano-technology, n. The journal covers cal applications of sury al

y to all bran uscript file able for the

t be longer u.u... a telegraphic style detrime derstanding of the paper. The **Title** should be as c enough to facilitat

"Informative enough to facilitate information retrieval. "Part 1," or simply "1," will not be included as part of he title of an article unless Part 2 has already been submitted for publication in the Journal. Part 3, 4, etc., are likewise unacceptable unless the prior parts have lready been accepted or have appeared in this Journal, and are properly identified in the references. The **Abstract** should be self-contained (contain no potnotes). It should be adequate as an image.

show ations or tabular m. **Authors' names** shoul 'and form for all publi full

Equations ag out their thematical o shou struc and g nd aligned to on the right. continuity of

the expression should be placed at the left of the second and succeeding lines.
Notation must be legible, clear, compact, and consistent with standard usage. All unusual symbols the first time they appear, and at all subsequent times when confusion might arise. Superscripts are normally set directly over subscripts; authors should note where readability or the meaning requires a special order. Separate **Tables** (numbered with Roman numerals in the order of their appearance in the text) should be used for all but the simplest tabular material; they should have captions that make the tables intelligible without reference to the text. The structure should be clear, with simple column headings giving all units. Unaltered computer output and notation are generally unacceptable. **References** are treated alike. They must be numbered consecutively in order of first appearance in the text and should be given in a separate double-spaced list at the end of the text material. References should be made to the full list of authors, rather than to first author is should be sent with the manuscript. Citation in the text should be by numbers in square brackets, for examples (1), [2], [3-6].
In the list of references, the following examples

- 2

- Malay K. Ghosh, K. L. Mittal, Polyimides-Fundamental and Applications, 285, Marcel Derkker, Incl. New York-Basel-Hong Kong (1996). Example of Book.
 John D. Hand- Wendell G. Whitehouse, Solution Process for the preparation of polyimides from diamines and anhydrides, United States Patent 3.996.203 (1976). Example of Patent
 J. Amstrong, H. Decker, Study on the polysaccharides from marine sponge, J. Nat. Prod., Vol 50, pp. 215-219 (2010). Example of Journal.
 J. Y. Kim, D. Y. Lee and W. S. Cho, in Light Weight Alloys for Aerospace Applications II, E. W. Lee and N. J. Kim, Eds., TMS, Warrendale, PA, pp. 467-479 (1991). - Example of Conference Proceedings
 D. H. Kim: Ph. D. thesis, Oxford University, (1989). Example of Unpublished Papers.

For further information, please contact: Doan Thi Yen Oanh, Editor Vietnam Journal of Chemistry Block 16, Vietnam Academy of Science and Technolo 18 Hoang Quoc Viet, Cau Giay, Hanoi Vietnam. Telephone: 84 (4) 37917412. E-mail: tchh@vjs.ac.vn; tchh62@vjs.ac.vn. ology

© Vietnam ⊳ emy of Sci and Technology (VAST)

Vietnam Journal of CHEMISTRY

VIETNAM JOURNAL OF CHEMISTRY

DC Jourr

ISSN 2525

Volume 54, Number 6, December 2016

Vol.54 (6-2016)

tock Cor Printed at Hoang Quoc Viet Technology and Science Join Index: 12873. Copyright deposit December 2016. 30.000 VND

¥

Structures of 2,5-diaryl- and 2,3,5,6-tetra[3,2-b]thiophene synthesized by the palladium-catalyzed Suzuki-Miyaura cross-coupling reaction

Nguyen Hien^{1*}, Nguyen Bich Ngan¹, Nguyen Dang Dat¹, Luc van Meervelt²

¹Faculty of Chemistry, Hanoi National University of Education ²Department of Chemistry, KU Leuven

Received 10 August 2016; Accepted for publication 19 December 2016

Abstract

The crystal structures of 2,5-di(ethoxyphenyl)-3,6-dibromothieno[3,2-*b*]thiophene (**I**) and 2,5-di(ethoxyphenyl)-3,6-diphenylthieno[3,2-*b*]thiophene (**II**) have been studied in order to evaluate the planarity of these molecules. The aromatic systems introduced to the thieno[3,2-*b*]thiophene core structure show a degree of rotation from 30.94° to 66.56°. The crystal packing of (**I**) are characterized by $\pi \cdots \pi$ stacking, while in (**II**), C-H $\cdots \pi$ and C-H \cdots O interactions are observed.

Keywords. thieno[3,2-b]thiophene, palladium-catalyzed, Suzuki-Miyaura, cross-coupling.

1. INTRODUCTION

Thieno[3,2-*b*]thiophene possesses rigid a structure and an extended π -conjugation. This electron-rich two annulated thiophene structure enable it to construct conjugated and low band gap organic semiconductors. Functionalized thieno[3,2b]thiophene units have been incorporated into, or designed as a part of the skeleton of conjugated oligomers and polymers to improve the electronic properties of the materials [1]. These kinds of materials were applied to produce high-performance organic field-effect transistors (OFETs) [2], organic light-emitting diodes (OLEDs) [3], and photovoltaics devices [4]. In fact, the performance of a functionalized material depends heavily on its molecular structure and the stacking motif. Therefore, design of functional molecular solid-state structures, or arrangements, through tuning of the intermolecular interactions is essential.

One of the convenient methods for fine-tuning band gaps involves the arylation which promotes a greater conjugation in the ground state. This method is also employed for adjusting the band gap of organic materials and increasing intermolecular interactions in the solid state. The objective of this work was the partial and full functionalization of the thieno[3,2-*b*]thiophene ring starting from 2,3,5,6tetrabromothieno[3,2-*b*]thiophene [5] using the palladium-catalyzed Suzuki-Miyaura cross-coupling reaction [6]. Herein, the synthesis, the molecular and the crystal structures of the synthesized 2,5di(ethoxyphenyl)-3,6-dibromothieno[3,2-

b]thiophene (I) and 2,5-di(ethoxyphenyl)-3,6-diphenylthieno[3,2-b]thiophene (II) will be discussed.



2. EXPERIMENTAL

2.1. Chemicals



Catalysts, solvents and other chemicals were purchased from Sigma-Aldrich or Merck and were used as received unless otherwise indicated. THF were refluxed over sodium wire in the presence of benzophenone as indicator and redistilled just before used. The Suzuki-Miyaura cross-coupling reactions were conducted under deaerated conditions.

2.2. Instrumentation

The ¹H NMR and ¹³C NMR spectra were recorded on a Bruker Avance 500 NMR spectrometer in CDCl₃. Chemical shift was reported in ppm units with tetramethylsilane (TMS) as internal reference. Splitting patterns are designated as s (singlet), d (doublet), t (triplet), q (quartet) and m (multiplet). X-ray measurements were performed on an Agilent SuperNova (single source at offset, Eos detector) diffractometer at the Department of Chemistry, KU Leuven, Belgium.

2.3. Synthesis and crystallization

2.3.1. Synthesis of 2,5-di(ethoxyphenyl)-3,6dibromothieno[3,2-b]thiophene (**I**)

Toluene (4 ml) was deoxygenated and saturated with argon by exchanging between vacuum and a stream of argon (3 times). 2.3.5.6-Tetrabromothieno[3,2-b]thiophene (230 mg, 0.5 mmol, 1.0 equiv) and $Pd(Ph_3P)_4$ (57.7 mg, 0.05 mmol, 0.10 equiv) were dissolved in this solvent at 60-70 °C. To the obtained solution was added H₂O (1 ml), K₃PO₄ (212 mg, 1.0 mmol, 2.0 equiv), and 4ethoxyphenylboronic acid (182.6 mg, 2.2 equiv). The reaction was vigorously stirred under argon atmosphere at 110 °C until TLC (100 % n-hexane) showed the complete consumption of the starting material (about 8 hours). The reaction mixture was cooled by ice water. The white solid separated was filtered, washed several times with toluene and recrystallized from hot *n*-hexane:ethyl acetate (1:1, v/v) to give (I) (155.5 mg, yield 58 %) as white needles; mp 230-231 °C. ¹H NMR (CDCl₃, 500 MHz): δ (ppm) 7.36 (t, J = 8.0 Hz, 1 H, *aromatic*), 7.27 (m, 2 H, aromatic), 6.95 (m, 1 H, aromatic), 4.10 (q, J = 7.0 Hz, 2 H, C<u>H</u>₂), 1.45 (t, J = 7.0 Hz, 3 H, CH_3); ¹³C NMR (CDCl₃, 125 MHz): δ (ppm) 159.1 (C-O), 139.4, 138.8, 134.0, 129.8, 121.3, 115.2, 114.9, 100.1, 63.6 (O-<u>C</u>H₂), 14.8 (<u>C</u>H₃).

2.3.2. Synthesis of 2,5-di(ethoxyphenyl)-3,6diphenylthieno[3,2-b]thiophene (**II**)

(I) (108 mg, 0.2 mmol) and $Pd(Ph_3P)_4$ (24 mg, 0.02 mmol, 0.10 equiv) were dissolved in toluene (4 ml) that was degassed and saturated with argon. To the mixture were added phenylboronic acid (47 mg,

0.44 mmol), K₃PO₄ (170 mg, 4.0 equiv) and distilled water (1 ml). The resulting mixture was refluxed at 110 °C, during which the progress of the reaction was monitored by TLC (100 % n-hexane). After 8 h, phenylboronic acid (21 mg, 0.2 mmol) and $Pd(Ph_3P)_4$ (12 mg, 0.01 mmol, 0.05 equiv) were added; the mixture was further refluxed for 12 h. After the reaction was completed, the reaction mixture was diluted with 20 ml toluene, washed with water (3 times) and dried over anhydrous Na₂SO₄. (II) was isolated by column chromatography (nhexane:ethyl acetate 95:5, v/v) as a white solid (64 mg, yield 60 %); mp 231-233 °C. (II) was further purified by recrystallized from n-hexane:ethyl acetate (3:1, v/v) solution. ¹H NMR (CDCl₃, 500 MHz): δ (ppm) 7.48 (dd, J = 8.0 Hz and 1.0 Hz, 2 H, *aromatic*), 7.37 (dt, J = 8.0 Hz and 1.0 Hz, 2 H, aromatic), 7.33 (d, J = 8.5 Hz, 1 H, aromatic), 7.16 (t, J = 8.0 Hz, 1 H, aromatic), 6.92 (td, J = 7.5 Hz and 0.5 Hz, 1 H, aromatic), 6.86 (m, 1 H, aromatic), 6.79 (m, 1 H, aromatic), 3.86 (q, J = 7.0 Hz, 2 H, C<u>H</u>₂), 1.13 (t, J = 7.0 Hz, 3 H, C<u>H</u>₃). ¹³C NMR (CDCl₃, 125 MHz): δ (ppm) 158.9 (<u>C</u>-O), 139.0, 138.9, 135.7, 135.2, 130.8, 129.5, 129.1, 128.8, 127.7, 121.6, 114.8, 114.6, 63.3 (O-CH₂), 14.7 (CH₃).

2.4. Structure solution and refinement

The X-ray diffraction data were collected on an Agilent SuperNova diffractometer using mirrormonochromated Mo K_{α} radiation ($\lambda = 0.71073$ Å). Using Olex2 [7]. The structure was solved with the SHELXS [8] structure solution program using Direct Methods and refined by full-matrix least-squares methods based on F^2 using SHELXL [9]. All nonatom parameters were hydrogen refined anisotropically. All hydrogen atoms were placed in idealized positions and refined in riding mode with U_{iso} values assigned as 1.2 times those of the parent atoms (1.5 times for methyl groups), with a C-H distance of 0.95 (aromatic), 0.98 (methyl) or 0.99 Å (methylene). The crystal data, the data collection, and the structure refinement details are summarized in table 1.

3. RESULTS AND DISCUSSION

The molecular structures of the diaryl (I) and tetraaryl (II) derivatives of thieno[3,2-b]thiophene are shown in Fig. 1. The bond lengths and angles are in good agreement with the average values in the Cambridge Structure Database (CSD, version 5.37, November 2015) [10].

In order to enlarge the π -conjugated system of

the thieno[3,2-b]thiophene, aromatic rings were introduced into the thieno[3,2-b]thiophene skeleton by Suzuki-Miyaura cross-coupling reactions. In

these reactions, the site-selectivity at the C2 and C5 positions was observed due to the effect of the sulphur heteroatom [10].

Table 1: Crystal data, data collection and	structure refinement parameters t	for (I)	and	(\mathbf{II}))
--	-----------------------------------	---------	-----	-----------------	---

	(I)	(II)
CSD code	CSD 1497991	CSD 1497992
Chemical formula	$C_{22}H_{18}Br_2O_2S_2$	$C_{34}H_{28}O_2S_2$
M _r	538.30	532.68
Crystal system, space group	Monoclinic, $P2_1/n$	Triclinic, P-1
Temperature (K)	100	100
<i>a</i> , <i>b</i> , <i>c</i> (Å)	3.9155(3), 14.7861(11),	5.7894(5), 9.3851(11), 13.4001(14)
	17.4836(14)	
$\alpha, \beta, \gamma(^{\circ})$	90, 91.395(7), 90	82.144(9), 84.093(8), 75.788(9)
$V(\text{\AA}^3)$	1011.92(13)	697.35(13)
Ζ	2	1
Radiation type	ΜοΚα	MoK_{α}
$\mu (\mathrm{mm}^{-1})$	4.23	0.22
Crystal size (mm ³)	$0.3 \times 0.1 \times 0.1$	$0.45 \times 0.12 \times 0.08$
Data collection		
T_{min}, T_{max}	0.679, 1.000	0.638, 1.000
No. of measured, independent	10583, 2054, 1917	14116, 2842, 2541
and observed $[I > 2\sigma(I)]$		
reflections		
$R_{\rm int}$	0.033	0.047
$(\sin\theta/\lambda)_{\rm max}$ (Å ⁻¹)	0.625	0.625
Refinement		
$R[F^2 > 2 \sigma(F^2)], wR(F^2), S$	0.020, 0.048, 1.07	0.040, 0.104, 1.07
No. of reflections	2054	2842
No. of parameters	128	173
$\Delta \rho_{\rm max}, \Delta \rho_{\rm min} ({\rm e} {\rm \AA}^{-3})$	0.36, -0.25	0.47, -0.27

Compound (I) crystallizes in space group $P2_1/n$, while (II) crystallizes in space group P-1. Both compounds have an inversion centre located in the middle of the C1-C1¹ bond in (I) and C2-C2ⁿ bond in (II) (Symmetry codes: (i) -x, -y + 1, -z + 1; (ii) -x + 11, -y + 1, -z; Fig. 1). As a result, the asymmetric unit consists of one half of the molecule, the second half being generated by an inversion centre. The fused thiophene rings in both structures are planar (r.m.s. deviation = 0.002 Å for (I) and 0.001 Å for (II)). The introduced phenyl rings are non-planar with the core structure. In (I), the dihedral angle between the thieno[3,2-b]thiophene ring and the ethoxyphenyl ring is 46.93(8)°. The rotation is to reduce the repulsion between Br1...H5 and S1...H9, that is in good agreement with the case of 3,6-dibromo-2(4tert-butylphenyl)-5-(4-methylstyryl)thieno[3,2-

b]thiophene [12]. In (II), the dihedral angles between the thieno[3,2-b]thiophene ring and the two

rings are 31.24(6)° and $66.61(7)^{\circ}$. phenyl respectively. In addition, in this compound, the ethoxyphenyl ring is almost perpendicular to the phenyl ring (the dihedral angle between both rings is 64.09(8)°). Only one tetra-substituted thieno[3,2b]thiophene structure similar to (II) is present in the 2,3,5,6-tetraphenylthieno[3,2-b]thiophene CSD: (refcode WEXBOS, [12]). In that case, the 2,5phenyl rings and the 3,6-phenyl rings are rotated out of the plane of the thieno [3,2-b] thiophene ring by dihedral angles of 35.31(7) and $59.38(6)^{\circ}$, respectively. Possibly, the ethoxy-substituted phenyl groups force the un-substituted ones to rotate less from the core structure, while they themselves are twisted more The packing of (I) shows π - π stacking between the 4-ethoxyphenyl rings $[Cg1...Cg1^{i} =$ 3.9155(3) Å; Cg1 is the centroid of the C4-C9 ring; symmetry code: (i) x + 1, y, z; Fig. 2a]. A weak C-Br... π interaction is observed [C2-Br1...Cg1ⁱⁱ;

Br1...*Cg*1ⁱⁱ = 3.9290(9) Å; symmetry code: (ii) -x + 1, -y + 1, -z + 1].



Figure 1: Molecular structures of (I) and (II), showing the atom-labelling schemes. Displacement ellipsoids are drawn at the 50% probability level. [Symmetry codes: (i) -x, -y + 1, -z + 1; (ii) -x + 1, -y + 1, -z]

Due to the presence of the four bulky substituents, the packing of (II) shows no π - π stacking (Fig. 2b), which is in agreement with the analogous structure 2,3,5,6-tetraphenylthieno[3,2-*b*]thiophene [12]. C-H···O interactions are present in the crystal packing resulting in a chain of molecules in the (204) plane. Parallel chains of the molecules

are linked by C-H··· π interactions with the ethoxysubstituted phenyl groups (table 2, Fig. 2b).

Possible intermolecular $S \cdots S$ interactions which could increase the electronic transport between neighboring molecules are not observed in the crystal packing of both (I) and (II).

D-H···A	D-H	H···A	D····A	D-H…A
C14-H14…O17 ⁱ	0.95	2.54	3.476(2)	168
C6-H6··· $Cg1^{ii}$	0.95	2.67	3.515(2)	148
C19-H19C… <i>Cg</i> 2 ⁱⁱⁱ	0.98	2.87	3.697(2)	143

Table 2: Hydrogen bond geometry (Å, °) for (II)

Symmetry codes: (i) -*x* - 1, -*y* - 1, -*z* - 1; (ii) *x* + 1, *y*, *z*; (iii) -*x*, -*y* + 1, -*z* + 1.

4. CONCLUSION

In conclusion, the crystal structures of a 2,5diaryl- and a 2,3,5,6-tetraayl derivatives of thieno[3,2-b]thiophene were recorded and analyzed. The results showed that the phenyl rings introduced into the thieno[3,2-b]thiophene core structure undergo a degree of rotation from 30.94° to 66.56°. In addition, $\pi \cdots \pi$ stacking is the dominant arrangement in the crystal packing of (I). On the other hand, C-H··· π and C-H···O interactions are in the crystal structure observed of (**II**). S...S interactions Intermolecular which could between increase the electronic transport neighboring molecules are not found in the crystal packing of both (I) and (II). Attempts to planarize the introduced aromatic rings with the thieno[3,2b]thiophene by the FeCl₃-oxidation reaction are in

progress in our laboratory and will be reported in near future.

Acknowledgements. This research is funded by the Vietnam National Foundation for Science and Technology Development (NAFOSTED) under grand number 104.01-2012.26. The authors thank VLIR-UOS (project ZEIN2014Z182) for financial support and the Hercules Foundation for supporting the purchase of the diffractometer through project AKUL/09/0035.

REFERENCES

1. Cinar M. E., Ozturk T., *Thienothiophenes, dithienothiophenes,* and *thienoacenes: syntheses, oligomers, polymers, and properties,* Chem. Rev., **115**, 3036 (2015).



Figure 2: (a) π - π stacking in (**I**); (b) partial crystal packing of (**II**) showing C-H··· π (grey) and C-H···O (red) interactions

- Chen Z., Lee M. J., Ashraf R. S., Gu Y., Albert-Seifried S., Nielsen M. M., Schroeder B., Anthopoulos T. D., Heeney M., McCulloch I., Sirringhaus H. High-performance ambipolar diketopyrrolopyrrolethieno[3,2-b]thiophene copolymer field-effect transistors with balanced hole and electron mobilities, Adv. Mater., 24, 647 (2012).
- Tang W., Ke L., Tan L., Lin T., Kietzke T., Chen Z.-K. Conjugated copolymers based on fluorenethieno[3,2-b]thiophene for light-emitting diodes and photovoltaic cells, Macromolecules, 40, 6164 (2007).
- Chen Z., Lee M. J., Ashraf R. S., Gu Y., Albert-Seifried S., Nielsen M. M., Schroeder B., Anthopoulos T. D., Heeney M., McCulloch I., Sirringhaus H. High-performance ambipolar diketopyrrolopyrrolethieno[3,2-b]thiophene copolymer field-effect transistors with balanced hole and electron mobilities, Adv. Mater., 24, 647 (2012).
- Fuller L. S., Iddon B., Smith K. A. Synthesis, metallation and bromine → lithium exchange reactions of thieno[3,2-b]thiophene and its polybromo derivatives, J. Chem. Soc., Perkin Trans., 1, 3465 (1997).

- Maluenda I., Navarro O. Recent Developments in the Suzuki-Miyaura Reaction: 2010-2014, Molecules, 20, 7528 (2015).
- Dolomanov, O. V., Bourhis, L. J., Gildea, R. J., Howard, J. A. K., Puschmann, H. OLEX2: a complete structure solution, refinement and analysis program, J. Appl. Cryst., 42, 339 (2009).
- 8. Sheldrick, G.M., A short history of SHELX, Acta Cryst., A64, 112 (2008).
- 9. Sheldrick, G.M., *Crystal structure refinement with SHELXL*, Acta Cryst., **C71**, 3 (2015).
- Groom, C. R., Bruno, I. J., Lightfoot, M. P., Ward, S. C. *The Cambridge structural database*, Acta Cryst., **B72**, 171 (2016).
- Dang T. T., Dang T. T., N. Rasool, A. Villinger, H. Reinke, C. Fischer, P. Langer. *Regioselective* palladium(0)-catalyzed cross-coupling reactions and metal-halide exchange reactions of tetrabromothiophene: optimization, scope and limitations, Adv. Synth. Catal., 351, 1595 (2009).
- 12. Nguyen H., Nguyen B. N., Dang T. T., Meervelt L. V. Stacking patterns of thieno[3,2-b]thiophenes

structure,

crystal

functionalized by sequential palladium-catalyzed Suzuki and Heck cross-coupling reactions, Acta Cryst., **C70**, 895 (2014).

13. Liu Y., Liu Q., Zhang X., Ai L., Wang Y., Peng

Corresponding author: Nguyen Hien

Faculty of Chemistry Hanoi National University of Education 136, Xuan Thuy, Cau Giay, Hanoi E-mail: hiennguyendhsphn@gmail.com; Telephone: 0983825316.

R., Ge

(2013).

Z.

Synthesis,

and polymerization of butterfly-shaped thieno[3,2-

b]thiophene oligomers, New J. Chem., 37, 1189

TABLE OF CONTENTS

		Page
121	Cyclopeptide alkaloid and lignans from Antidesma hainanensis Merr.	663
	Le Canh Viet Cuong, Do Thi Trang, Nguyen Xuan Nhiem, Pham Hai Yen, Bui Huu Tai, Hoang Le Tuan Anh, Le Mai Huong, Chau Van Minh, Phan Van Kiem	
122	Synthesis and structure of two platinum(II) complexes containing methyl eugenoxyacetate and 2-aminobenzothiazoles.	667
	Nguyen Thi Thanh Chi, Nguyen Thi Hoa	
123	Structures of 2,5-diaryl- and 2,3,5,6-tetra[3,2- <i>b</i>]thiophene synthesized by the palladium-catalyzed Suzuki-Miyaura cross-coupling reaction.	672
	Nguyen Hien, Nguyen Bich Ngan, Nguyen Dang Dat, Luc van Meervelt	
124	Megastigmans and other compounds from Antidesma hainanensis Merr.	678
	Le Canh Viet Cuong, Do Thi Trang, Nguyen Xuan Nhiem, Pham Hai Yen, Bui Huu Tai, Hoang Le Tuan Anh, Le Mai Huong, Chau Van Minh, Phan Van Kiem	
125	Comparison of the degradability of various polyethylene films containing pro-oxidant additive.	683
	Pham Thu Trang, Nguyen Quang Huy, Nguyen Van Khoi, Pham Thi Thu Ha, Nguyen Thanh Tung	
126	Cytotoxic steroids from the mushroom Ganoderma australe collected in Laos.	688
	Onesy Keomanykham, Vong Anatha Khamko, Bounpong Keorodom, Sitha Khemmarath, Dang Ngoc Quang	
127	A benzothiazolium-derived colorimetric and fluorescent chemosensor for detection of $\mathrm{Hg}^{2^{+}}$ ions.	692
	Doan Thanh Nhan, Nguyen Khoa Hien, Nguyen Thi Ai Nhung, Nguyen Van Binh, Nguyen Chi Bao, Duong Tuan Quang	
128	Mn(III)-induced reaction of 1,1-diarylethenes with potassium thiocyanate: a novel synthesis of dithiocyanates.	699
	Nguyen Van Ha, Tran Thi Bao Quyen	
129	High-energy ball milling preparation of $La_{0.7}Sr_{0.3}MnO_3$ and (Co,Ni)Fe_2O_4 nanoparticles for microwave absorption applications.	704
	Chu Thi Anh Xuan, Ta Ngoc Bach, Tran Dang Thanh, Ngo Thi Hong Le, Do Hung Manh, Nguyen Xuan Phuc, Dao Nguyen Hoai Nam	
130	Anticancer agents of kaempferol-3-O-methylether and kaempferol-3-O-(2,4-O-diacetyl-alpha-L-rhamnopyranoside) in leaf of plants <i>Zingiber zerumbet</i> SM using 2D, 3D descriptors.	710
	Bui Thi Phuong Thuy, Nguyen Thi Ai Nhung, Vo Thanh Cong, Phung Van Trung, Hoang Thi Kim Dung, Tran Duong, Pham Van Tat	

131	Effect of nanosilica/chitosan hybrid on leaf blast and blight diseases of rice in Vietnam.	719
	Le Nghiem Anh Tuan, Lai Thi Kim Dung, Nguyen Quoc Hien, Dang Van Phu, Bui Duy Du	
132	Electrochemical properties of $LiNi_{0.8}Co_{0.1}Mn_{0.1}O_2$ synthesized by sol-gel and co-precipitation methods.	724
	Mai Thanh Tung, Vu Duc Luong	
133	Synthesis and characterization of polythiophenes from hydrazone derivatives sidegroups.	730
	Vu Quoc Trung, Nguyen Ngoc Linh, Duong Khanh Linh, Jiri Pfleger	
134	Direct electrocatalytic activity of chicken liver sulfite oxidase immobilized on binary self- assembled monolayer composed of separated domains having opposite charges.	736
	Pham Hong Phong	
135	A study on the corrosive inhibition ability of CT3 steel in 1 M HCl solution by caffeine and some characteristics of the inhibition process.	742
	Truong Thi Thao, Hoang Thi Phuong Lan, Ngo Duong Thuy	
136	Synthesis and bioactivity evaluation of 2-aza-anthraquinones.	747
	Nguyen Van Tuyen, Pham The Chinh, Le Nhat Thuy Giang, Vu Thi Thu Ha, Dang Thi Tuyet Anh, Hoang Thi Phuong, Nguyen Ha Thanh, Pham Thi Tham, Nguyen Quang Trung	
137	Membrane scaling during seawater desalination by direct contact membrane distillation.	752
	Duong Cong Hung, Pham Manh Thao, Luong Trung Son, Huynh Thai Nguyen, Nghiem Duc Long	
138	Synthesis, structural and electrochemical properties of Ni-rich material prepared by a sol-gel method.	760
	Mai Thanh Tung, Vu Duc Luong	
139	Synthesis of ZnO nanorod for immunosensor application.	765
	Vu Y Doan, Pham Hung Vuong, Hoang Lan, Phuong Dinh Tam	
140	Preparation of Ti/TiO ₂ -PANi electrodes by combining method of thermal treatment with polymerization processing and their electrochemical property.	771
	Mai Thi Xuan, Nguyen The Duyen, Pham Thi Tot, Mai Thị Thanh Thuy, Nguyen Thi Van Anh, Phan Thi Binh	
141	Tensile, electrical properties and morphology of polyethylene/modified fly ash composites using ultraflow.	776
	Nguyen Thuy Chinh, Tran Thi Mai, Nguyen Thi Thu Trang, Nguyen Vu Giang, Tran Huu Trung, Nguyen Thi Thanh Huong, Thai Hoang	
142	Chemical constituents of fruits of Khaya senegalensis A. Juss growing in Vietnam.	781
	Vu Thi Hien, Vu Dinh Hoang	
143	Steroids from the blood cockle Anadara granosa.	786
	Phan Thi Thanh Huong, Nguyen Hoang Giang, Tran Thi Hong Hanh, Do Cong Thung, Nguyen Xuan Cuong, Nguyen Van Thanh, Chau Van Minh	
144	Kaempferol and its glycosides from Phyllanthus acidus leaves.	790
	Nguyen Cong Thuy Tram, Ninh The Son, Do Thi Thao, Nguyen Manh Cuong	