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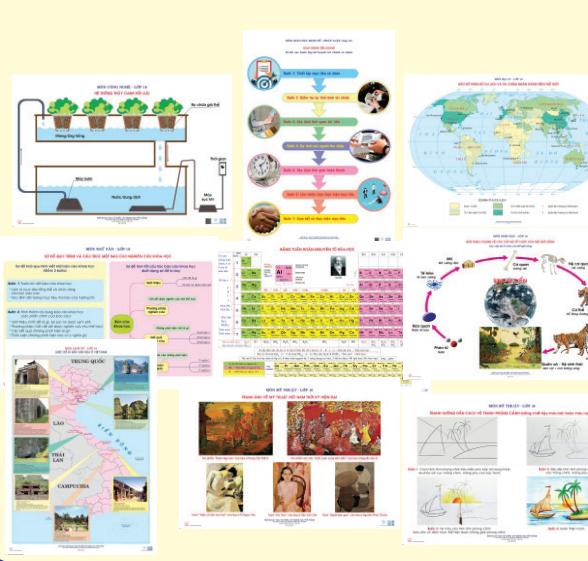
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TẠP CHÍ HÓA HỌC & ỨNG DỤNG

JOURNAL OF CHEMISTRY AND APPLICATION / TẠP CHÍ CỦA HỘI HÓA HỌC VIỆT NAM - ISSN1859-4069

Số 3B(70B)/5-2024

SỐ ĐẶC BIỆT HỘI NGHỊ HÓA HỌC HỮU CƠ TOÀN QUỐC LẦN THỨ X

(21 - 22/09/2024)

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CHARACTERIZATION OF ACRYLIC COATINGS CONTAINING POLY(TRIETHYLMONIUM 3-THIOPHENEACETATE) POLYELECTROLYTE AND NANO-SI_O₂

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SUMMARY:

The fabrication of acrylic coatings containing polythiophene-based conjugated polyelectrolyte and nano-SiO₂, using oxidative coupling polymerization to create the water-soluble polyelectrolyte triethylammonium poly(3-thiophene acetate), was successful. The chemical structure, morphology, and mechanical properties of acrylic/polythiophene/nano-SiO₂ coatings were characterized by Fourier Transform Infrared (FT-IR) spectroscopy, Field emission scanning electron microscope (FESEM), and measurements including abrasion resistance, gloss, and pencil hardness. The results indicated that adding polythiophene and nano-SiO₂ as reinforcing additives improved the mechanical properties of the acrylic coating. The acrylic coating with the nano-SiO₂ and polythiophene content of 2wt% and 2wt% achieved optimal properties in gloss, pencil hardness, and abrasion resistance results. The abrasion resistance of the coating was 346.4l/mil, and the gloss was 121.6 GU.

Keywords: Nano-SiO₂, polythiophene, polyelectrolyte, acrylic coating, abrasion resistance.

I. INTRODUCTION

In recent years, the development of organic paints and coatings has grown significantly due to the rising need for sustainability and aesthetics in buildings. The current problems in this area are the production of coatings with good mechanical properties, including hardness, gloss, weather resistance, and improvement of the material's surface qualities under environmental conditions. Acrylic resin coating, with its high adhesion strength, color stability enhancement, and weather resistance, is extensively employed[1-3]. Research has indicated that adding photo stabilizers, modified nanocomposite particles, or additives such as plasticizers, adhesives, and crosslinkers can improve these characteristics of acrylic coatings [4-6].

Currently, scientists and industry have paid particular attention to nanotechnology[7-9]. Among the used

nano-particles, nano-SiO₂ is studied and utilized in numerous high-tech manufacturing industries, such as drug carriers, corrosion inhibitors, antibacterial agents, or nanomaterials to reinforce polymer-based materials[10-13]. Incorporating nano-SiO₂ into the coating can provide it with novel, desirable properties while enhancing its mechanical, thermal, and anti-corrosion qualities. Additionally, using silane-grafted nano-SiO₂ or polymer-grafted nano-SiO₂ can improve the dispersion and compatibility of nano-SiO₂ in a polymer matrix[14-18]. For example, the grafting of poly(ethylene oxide) onto nano-silica has demonstrated enhanced dispersibility and adhesion of nano-SiO₂ in polyurethane coatings[19]. Upon adding nano-SiO₂ modified with some polythiophene to waterborne acrylic coatings, the UV absorption intensity and other mechanical

characteristics, including abrasion resistance, pencil hardness, and gloss, were improved[14]. This research highlights that using nano-silica and polythiophenes as additives can enhance the characteristics of acrylic coatings. In particular, water-soluble polythiophene derivatives or polyelectrolyte polythiophene are of special significance among CPEs due to a unique combination of good environmental stability, conductivity, and versatility of substituted π -conjugated backbone in various technical applications[20-22].

In our studies, nano-SiO₂ and polyelectrolyte polythiophene as reinforcing additives were added to acrylic coatings, aiming to enhance the mechanical characteristics of coatings. Polyelectrolyte polythiophene was synthesized from poly(3-thiophene acetic acid) using an oxidative coupling polymerization reaction with FeCl₃ catalyst. The influence of nano-SiO₂ content on the mechanical characteristics of acrylic/polythiophene/nano-SiO₂ coatings, including gloss, pencil hardness, and abrasion resistance of coatings, were investigated.

II. EXPERIMENTAL

2.1. Chemicals

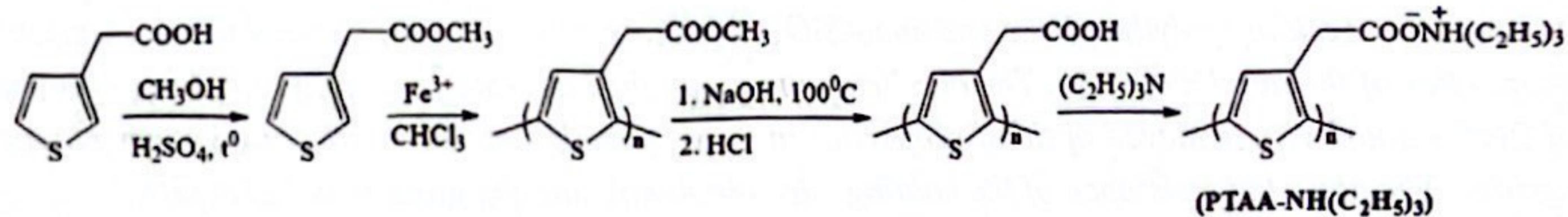
2-(Thiophen-3-yl)acetic acid, anhydrous iron (III) chloride (98%), triethylamine, sulfuric acid (98%), hydrochloric acid (37%), sodium hydroxide, methanol, and chloroform (all obtained from Merck), and nano-SiO₂ (from rice husk ash, ~50-200nm) were directly used as purchased.

Acrylic emulsion resin Plextol R 4152, which has a total solids content of 50%, pH of 7-8.5, a viscosity of 500-

3,000cps, and particle size of 0.13 μ m, was purchased from Synthomer Company, USA.

2.2. Fabrication of acrylic R4152 coatings containing poly(triethylammonium 3-thiopheneacetate) polyelectrolyte and nano-SiO₂

2.2.1. Synthesis of poly(triethylammonium 3-thiopheneacetate) polyelectrolyte PTAA-NH(C₂H₅)₃



Scheme 1. The synthesis of poly(triethylammonium 3-thiopheneacetate) polyelectrolyte

The synthesis of poly(triethylammonium 3-thiopheneacetate) polyelectrolyte (PTAA-NH(C₂H₅)₃) was reported in our previous study[23].

2.2.2. Fabrication of acrylic coatings containing PTAA-NH(C₂H₅)₃ and nano-SiO₂

0.1g of PTAA-NH(C₂H₅)₃ was dissolved in 1ml of deionized water by TPC-15H Ultrasonic Bath Equipment with a capacity of 450W and a vibration frequency of 20kHz. This step was carried out for 120 minutes to ensure good dispersion of polyelectrolyte particles in water. After that, nano-SiO₂ and 10g of acrylic 4,152 resin were added to the mixture. The newly obtained mixture was further ultrasonically vibrated for 120 minutes and magnetic stirred for 2 hours with an IKA RW16 stirrer at 400rpm speed to disperse the nanoparticles evenly in the acrylic resin mixture. The mass compositions of the acrylic/polythiophene/nano-SiO₂ coatings (APS0.5, APS1, APS2, and APS4) are displayed in Table 1.

Table 1: Composition of acrylic coatings containing PTAA-NH(C₂H₅)₃ and nano-SiO₂

No.	Sample symbol	SiO ₂ (g)	PTAA-NH(C ₂ H ₅) ₃ (g)	H ₂ O (ml)	Acrylic R4152 (g)
1	A0	-	-	1.0	10
2	AP0	-	0.1	1.0	10
3	APS0.5	0.025	0.1	1.0	10
4	APS1	0.050	0.1	1.0	10
5	APS2	0.100	0.1	1.0	10
6	APS4	0.200	0.1	1.0	10

Coating A0 and AP0 were prepared using the same method to serve as a control sample.

The samples were created with a wet film thickness of 120 μ m using an Erichsen Film Applicator (model 360) on glass and concrete (equivalent to a dry film thickness

of $30 \pm 2 \mu\text{m}$). Before determining the characteristics and properties of the coating, the coating samples were allowed to dry for seven days under standard conditions. They were kept at standard temperatures of 25°C and 60% relative humidity for 24 hours before testing.

2.3. Devices and methods

FT-IR spectroscopy

FT-IR spectroscopy was investigated using a Nexus 670 ThermoNicolet Fourier Transform Infrared Spectrometer from Nicolet. The spectrum was scanned in the $4,000\text{--}400\text{cm}^{-1}$ range with a resolution of 8cm^{-1} , and the number of scans was 32 times.

Thermal stability

Thermo-gravimetry experiments were performed using a TGA-50 Shimadzu Thermal Analysis Instruments (Japan). The samples were heated from room temperature to 600°C at a rate of $10^\circ\text{C}/\text{min}$ with a flow rate of $50\text{cm}^3/\text{min}$.

Morphology

Structural morphology of the coatings was analyzed in a Hitachi S-4800 SEM instrument (Japan).

Abrasion resistance

Following ASTM D968-15 standard, the Falling Sand Abrasion TesterTM was used to evaluate the abrasion resistance of the coating by measuring the surface degradation when the paint film was under the falling sand force at a predefined height of 0.914 meters. Furthermore, the paint film thickness was deducted as the mean from 3 measures using the ElektroPhysik Minitest 600.

Gloss measurement

Erichsen Picogloss (model 503) was used to test the gloss at 60° angle of the formula coatings after an accelerated aging process according to ISO 2813:2014. The ratio of the aged coating's gloss to that of the original coating was used to calculate the gloss retention.

Pencil hardness

This technique assessed the hardness and scratch resistance of the film according to the ASTM D 3363 standard. The graphite scale ranged from 6B to 8H, the pencil tip was subjected to 500g of pressure, and the angle between the pencil and measuring surface was 45 degrees.

III. RESULTS AND DISCUSSION

3.1. Morphology of acrylic coatings containing PTAA-NH(C₂H₅)₃ and nano-SiO₂

The results show a relatively even distribution of the polythiophene and nano-SiO₂ particles throughout the polymer matrix (Figure 1). When adding polythiophene coating with 0.5wt%, 1 wt%, and 2wt% nano-SiO₂ (APS0.5, APS1, and APS2), all paint films have identical morphology. The nanoparticles are well-dispersed in the

polymer matrix, with only a few small clumps. However, when 4wt% of nano-SiO₂ particles are added to the APS4 coating, the SiO₂ nanoparticles tend to aggregate considerably, forming particle clusters that are tens of nm in size and leading to defective areas in the paint films.

Therefore, it is clear that the ideal outcomes are obtained with 1-2 wt% nano-SiO₂ particles and 2wt% polythiophene polyelectrolyte particles distributed throughout the acrylic resin system.

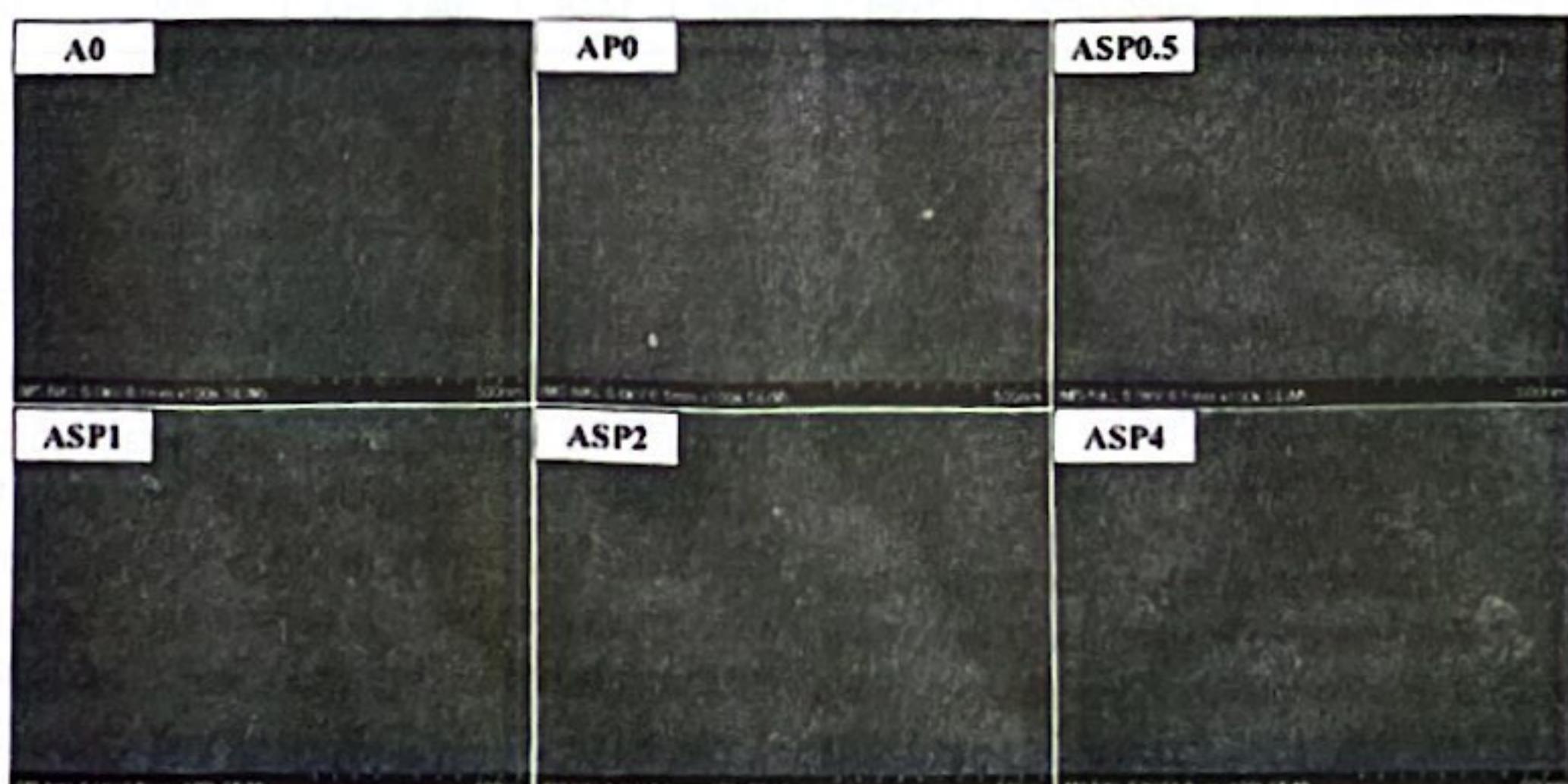


Figure 1. FE-SEM images of acrylic/ poly(triethylammonium 3-thiopheneacetate) polyelectrolyte/nano-SiO₂, coatings

3.2. FT-IR spectra of acrylic coatings containing PTAA-NH(C₂H₅)₃ and nano-SiO₂

Based on the IR spectra of all acrylic/poly(triethylammonium 3-thiopheneacetate) polyelectrolyte/nano-SiO₂ coatings (Figure 2) and some major vibrations of acrylic/polythiophene/nano-SiO₂ coatings (Table 2), it can be seen that the absorption spectra at 1,098cm⁻¹ and 808cm⁻¹ corresponding to the asymmetric and symmetric vibrations of the Si-O group in nano-SiO₂, respectively[24]. In the coating containing polyelectrolyte and acrylate systems, there are characteristic peaks for the vibration of the -C=O ester group at around 1,745–1,722cm⁻¹ and the vibration of the -CH sp³ group at around 2,946cm⁻¹. In addition, a strong blunt band at around 3,500cm⁻¹ characterizes the valence vibrations of -OH bonds of hydroxyl groups on the SiO₂ surface and -NH bond of the side group in polyelectrolyte. The characteristic band for the deformation vibration of the C-S bond of the thiophene ring is covered by the characteristic vibrational region of acrylate. The bands in the 1,400-1,100cm⁻¹ region of the bending mode of the C-C-O and C-C=O bonds belong to esters in the backbone chain[25].

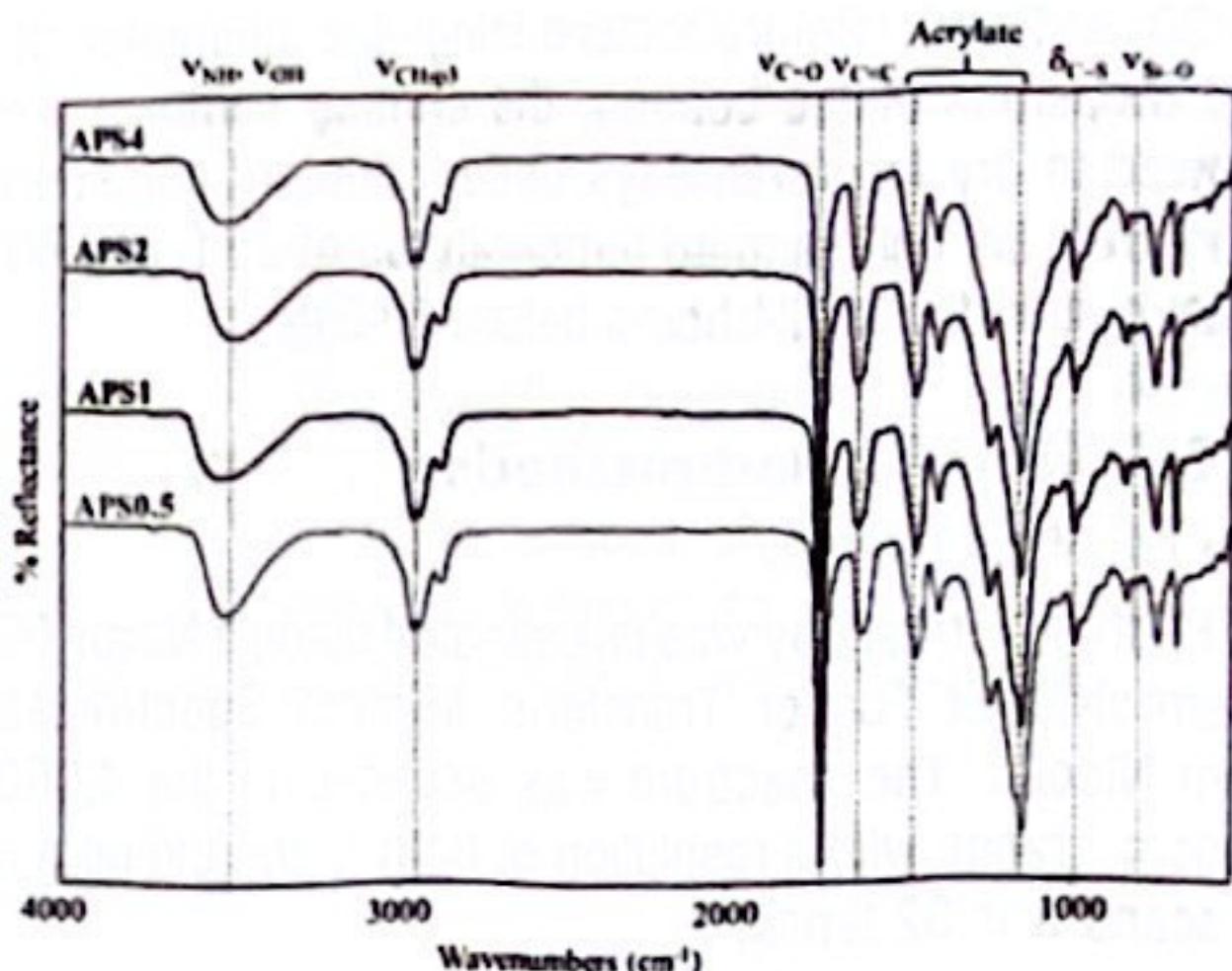


Figure 2. FT-IR spectra of acrylic/poly(triethylammonium 3-thiopheneacetate) polyelectrolyte/nano-SiO₂ coatings

Theoretically, the distinctive spectral bands for acrylate group bonds at 1,635cm⁻¹ and 982cm⁻¹ will almost disappear during the production of the acrylic/poly(triethylammonium 3-thiopheneacetate) polyelectrolyte/nano-SiO₂ paint system, indicating that these groups have taken part in the bonding process. The spectral bands at this point, however, continue to occur because they represent the deformation vibration of the C-S bond in polyelectrolyte PTAA-NH(C₂H₅)₃ and the vibration of the conjugated system C=C-C=C, respectively.

Table 2: Some major vibrations in IR spectrum (cm⁻¹) of acrylic/poly(triethylammonium 3-thiopheneacetate) polyelectrolyte/nano-SiO₂ coatings

Coating	ν _{N-H} , ν _{O-H}	ν _{-CH sp³}	ν _{C=O}	ν _{C=C}	ν _{C-C}	δ _{C-S}	ν _{Si-O}	Acrylate
APS0.5	3511	2949-2922	1728	1604	1448	1040; 989	809	1400-1100
APS1	3509	2952-2922	1729	1608	1448	1043; 983	809	1400-1100
APS2	3496	2946-2922	1722	1610	1445	985	810	1400-1100
APS4	3515	2952-2925	1745	1604	1445	986	809	1400-1100

3.3. Mechanical properties of acrylic coatings containing PTAA-NH(C₂H₅)₃ and nano-SiO₂

3.3.1. The gloss

Gloss is one of the necessary properties of the paint film surface. Figure 3 illustrates how the content of nano-SiO₂ affects the gloss of acrylic/polythiophene polyelectrolyte coatings. The control film A0 without SiO₂ and PTAA-NH(C₂H₅)₃ has the lowest gloss measured at 92.2 GU. The gloss of the paint film is enhanced with the presence

of PTAA-NH(C₂H₅)₃ (AP0), or both PTAA-NH(C₂H₅)₃ and nano-SiO₂ (APS0.5, APS1, APS2 and APS4). The paint film with the highest gloss result, measured at 121.6 GU, is APS0.5, which contains 2wt% nano-SiO₂. When nano-SiO₂ particles are in the 0.5–1 wt% range, they can fill the defect area and cover the surface of the coating. However, as the concentration of nano-SiO₂ particles increases to 4wt%, more surface flaws develop because of the excess nano-SiO₂, leading to a decrease in the gloss of the coating in the sample APS4.

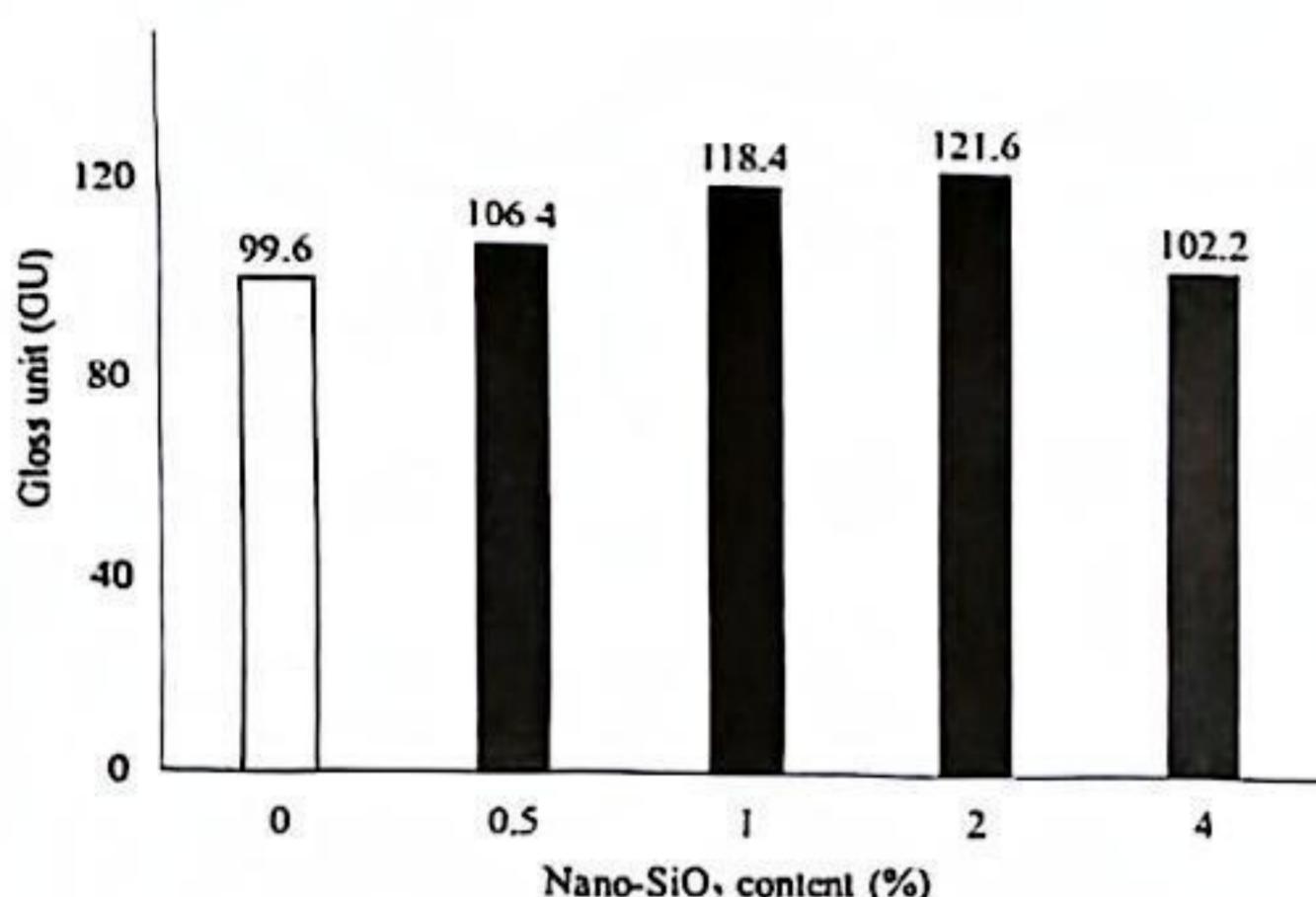


Figure 3. Influence of nano-SiO₂ content on the gloss of acrylic/poly(triethylammonium 3-thiopheneacetate) polyelectrolyte coatings

3.3.2. Abrasion resistance and pencil hardness

The influence of nano-SiO₂ content on the abrasion resistance and pencil hardness of acrylic/polythiophene coatings are presented in Figure 4 and Table 3.

Firstly, the mechanical properties of the coating are improved by the presence of nano-SiO₂ particles, and the results of pencil hardness and abrasion resistance are proportionate. These results reveal that the ideal relative hardness and pencil hardness values, or 346.4 l/mil and 2H, respectively, are found in the APS2 sample that contains 2wt% nano-SiO₂, whereas the control sample A0 exhibits the lower values of 91.4 l/mil and HB.

Secondly, the nano-SiO₂ content added to the coating in the range of 0.5wt% to 2wt% is proportionate to the abrasion resistance and pencil hardness values. Nevertheless, the abrasion resistance value of the APS4 sample drops to a value that is even lower than that of the APS0.5 sample, which contains 0.5% nano-SiO₂ content, when the silica concentration grows to 4wt%. This is because an excessive concentration of nano-SiO₂ can cause the agglomeration, resulting in uneven distribution of the particles throughout the sample and reducing the compactness of the material.

Third, the results of abrasion resistance and pencil hardness values of the coatings are also consistent with the FE-SEM image (Figure 1) and gloss (Figure 3) results.

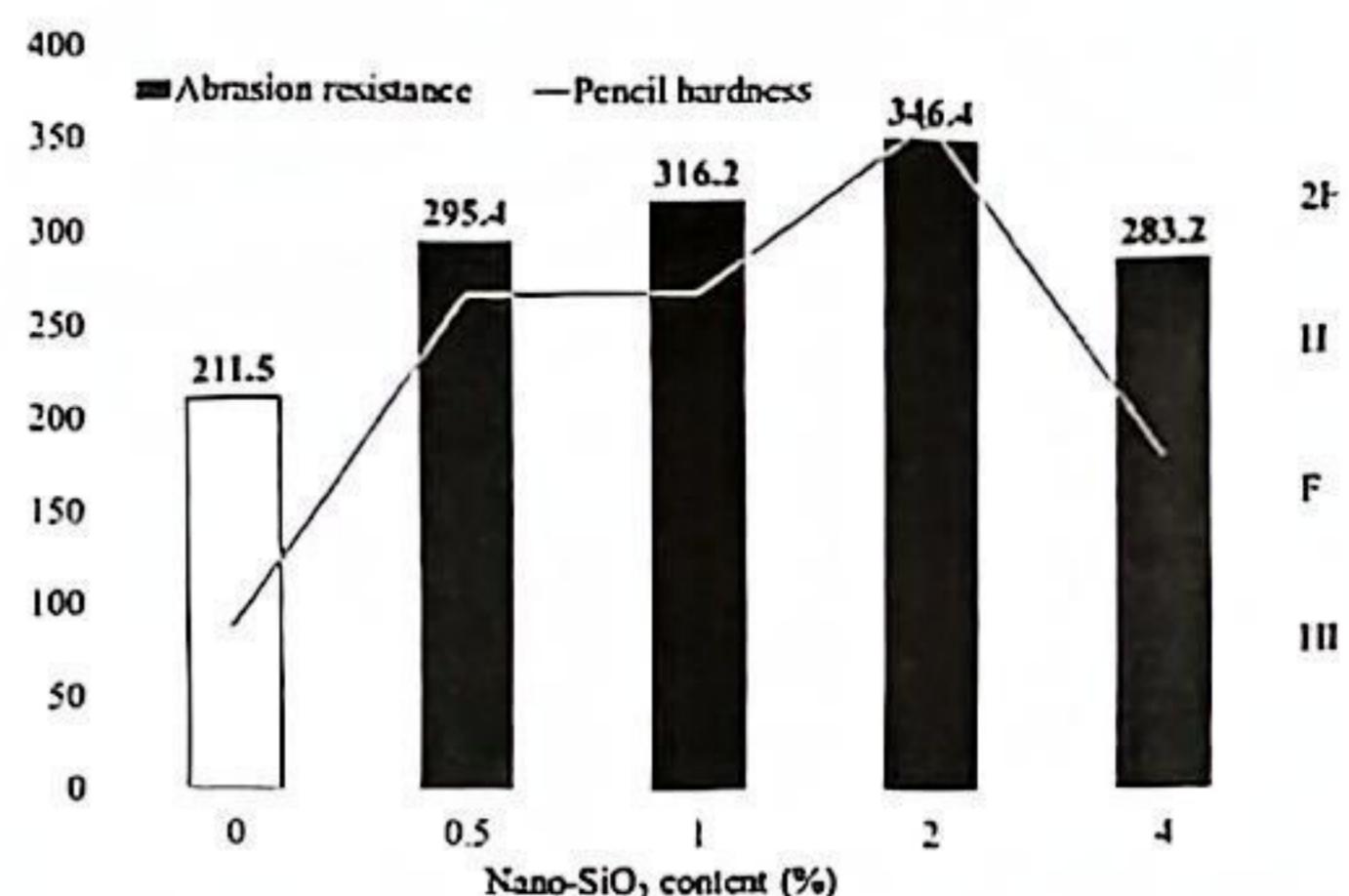


Figure 4. Influence of nano-SiO₂ content on the abrasion resistance and pencil hardness of acrylic/poly(triethylammonium 3-thiopheneacetate) polyelectrolyte coatings

Table 3: Effect of nano-SiO₂ on mechanical properties of acrylic/poly(triethylammonium 3-thiopheneacetate) polyelectrolyte coatings

No.	Mechanical characteristics	Content of nano-SiO ₂ , %				
		0	0.5	1	2	4
1	The gloss, GU	99.6	106.4	118.4	121.6	102.2
2	Pencil hardness	HB	H	H	2H	F
3	Abrasion resistance, L/mil	211.5	295.4	316.2	346.4	283.2

IV. CONCLUSION

Poly(triethylammonium 3-thiopheneacetate) polyelectrolyte (PTAA-NH(C₂H₅)₃) was synthesized from poly(3-thiophene acetic acid) using oxidative coupling polymerization reaction with FeCl₃ catalyst. Based on the highest water solubility, the polyelectrolyte was used as a reinforcing additive to improve the properties of acrylic coatings. Furthermore, the impact of nano-SiO₂ content on the mechanical properties of acrylic coatings that incorporate PTAA-NH(C₂H₅)₃ was investigated. The dispersion of polythiophene polyelectrolyte and nano-SiO₂ particles in the acrylic resin matrix was satisfactory, with 2wt% of each material for optimal outcomes. In addition, the presence of SiO₂ nanoparticles and polyelectrolyte polythiophene significantly improved the morphology, gloss, pencil hardness, and abrasion resistance of the acrylic coatings, with the best results achieved from the sample containing 2wt% both SiO₂ nanoparticles and polythiophene. In particular, at this content of poly(triethylammonium

3-thiopheneacetate) polyelectrolyte and nano-SiO₂, the abrasion resistance and gloss of the coating APS2, respectively, were 346.4 l/mil and 121.6 GU.

REFERENCES

- [1]. B. Du, F. Chen, R. Luo, S. Zhou and Z. Wu. *Synthesis and Characterization of Nano-TiO₂/SiO₂-Acrylic Composite Resin*, Advances in Materials Science and Engineering, 2019, 2019(1), 7 pages.
- [2]. S. Muradova, E.-S. Negim, A. Makhmetova, D. Ainakulova and N. M. I. Mohamad. *An Overview of the Current State and the Advantages of using acrylic resins as anticorrosive coatings*, Kompleksnoe Ispolzovanie Mineralnogo Syra = Complex use of mineral resources, 2023, 32 (4), 90-98.
- [3]. M. L. Nobel, E. Mendes and S. J. Picken. *Enhanced properties of innovative laponite-filled waterborne acrylic resin dispersions*, Journal of Applied Polymer Science, 2007, 103 (2), 687-697.
- [4]. C.-A. Xu, Z. Qu, H. Meng, B. Chen, X. Wu, X. Cui, K. Wang, K. Wu, J. Shi and M. Lu. *Effect of polydopamine-modified multi-walled carbon nanotubes on the thermal stability and conductivity of UV-curable polyurethane/polysiloxane pressure-sensitive adhesives*, Polymer, 2021, 223, 11 pages.
- [5]. T. X. H. To, T. D. Ngo, A. T. Trinh, T. D. Nguyen, V. T. Bui, G. V. Pham, H. Thai, T. M. T. Dinh and M.-G. Olivier. *Effect of silane modified nano ZnO on UV degradation of polyurethane coatings*, Progress in Organic Coatings, 2015, 79, 68-74.
- [6]. B. Pang, C.-M. Ryu, X. Jin and H.-I. Kim. *Preparation and properties of UV curable acrylic PSA by vinyl bonded graphene oxide*, Applied Surface Science, 2013, 285, 727-731.
- [7]. T. V. Nguyen, P. H. Dao, K. L. Duong, Q. H. Duong, Q. T. Vu, A. H. Nguyen, V. P. Mac and T. L. Le. *Effect of R-TiO₂ and ZnO nanoparticles on the UV-shielding efficiency of water-borne acrylic coating*, Progress in Organic Coatings, 2017, 110, 114-121.
- [8]. D. Chaudhari, T. Patil, P. Raichurkar and A. Daberao. *Review on Nanotechnology & Its Application in Coating Industry*, International Journal of Scientific and Engineering Research, 2018, 09, 13 pages.
- [9]. H. Boostani and S. Modirrousta. *Review of Nanocoatings for Building Application*, Procedia Engineering, 2016, 145, 1541-1548.
- [10]. N. L. Nguyen, T. M. L. Dang, T. A. Nguyen, H. T. Ha and T. V. Nguyen. *Study on Microstructure and Properties of the UV Curing Acrylic Epoxy/SiO₂ Nanocomposite Coating*, Journal of Nanomaterials, 2021, 2021(1), 9 pages.
- [11]. S. Mallakpour and M. Naghdi. *Polymer/SiO₂ nanocomposites: Production and applications*, Progress in Materials Science, 2018, 97, 409-447.
- [12]. O. Afzal, A. S. A. Altamimi, M. S. Nadeem, S. I. Alzarea, W. H. Almalki, A. Tariq, B. Mubeen, B. N. Murtaza, S. Iftikhar, N. Riaz and I. Kazmi. *Nanoparticles in Drug Delivery: From History to Therapeutic Applications*, Nanomaterials (Basel), 2022, 12(24), 27 pages.
- [13]. H. Kirla, D. J. Henry, S. Jansen, P. L. Thompson and J. Hamzah. *Use of Silica Nanoparticles for Drug Delivery in Cardiovascular Disease*, Clin Ther, 2023, 45(11), 1060-1068.
- [14]. D. T. T. Nguyen, D. B. Do, T. H. Nguyen, C. T. Nguyen, T. X. Nguyen, H. P. Dao, H. Thai, L. N. Nguyen, M. Q. Vu and T. Q. Vu. *Effect of silica nanocomposite modified with some polythiophene derivations on characteristics and properties of waterborne acrylic coatings*, Journal of Coatings Technology and Research, 2024.
- [15]. X. Gong and S. He. *Highly Durable Superhydrophobic Polydimethylsiloxane/Silica Nanocomposite Surfaces with Good Self-Cleaning Ability*, ACS Omega, 2020, 5(8), 4100-4108.
- [16]. X. Lv, J. Wang, Y. Guo and Y. Guo. *Preparation of UV-curable nano-SiO₂/acrylate coatings modified by P-containing LEPB and their applications on plywood*, Journal of Coatings Technology and Research, 2023, 20(6), 2031-2044.
- [17]. T. Nguyen, T. A. Nguyen and H. Nguyen. *The Synergistic Effects of SiO₂ Nanoparticles and Organic Photostabilizers for Enhanced Weathering Resistance of Acrylic Polyurethane Coating*, Journal of Composites Science, 2020, 4, 11 pages.
- [18]. S. Zhou, L. Wu, J. Sun and W. Shen. *The change of the properties of acrylic-based polyurethane via addition of nano-silica*, Progress in Organic Coatings, 2002, 45(1), 33-42.

[19]. B. Lin and S. Zhou. *Poly(ethylene glycol)-grafted silica nanoparticles for highly hydrophilic acrylic-based polyurethane coatings*, Progress in Organic Coatings, 2017, 106, 145-154.

[20]. F. Wang, M. Li, B. Wang, J. Zhang, Y. Cheng, L. Liu, F. Lv and S. Wang. *Synthesis and characterization of water-soluble polythiophene derivatives for cell imaging*, Sci Rep, 2015, 5, 8 pages.

[21]. Q. T. Vu, N. L. Nguyen, B. D. Do, C. T. Pham, H. H. Nguyen and M. L. Van. *Crystal structure and Hirshfield surface analysis of 4-phenyl-3-(thiophen-3-ylmethyl)-1H-1,2,4-triazole-5(4H)-thione*, Acta Crystallographica Section E Crystallographic Communications, 2018, 74, 812-815.

[22]. L. Wang, G. Zhang, M. Pei, L. Hu, E. Li and H. Li. *A novel water-soluble polythiophene derivatives based fluorescence "turn-on" method for protein determination*, Journal of Applied Polymer Science, 2013, 130(2), 939-943.

[23]. N. L. Nguyen, M. T. Tran, K. L. Duong, T. H. Vu, M. H. Ha, T. Y. O. Doan and Q. T. Vu. *Synthesis and characterization of poly(3-thiophene acetic acid) upon binding by cationic groups*, Vietnam Journal of Chemistry, 2021, 59(6), 902-909.

[24]. E. Rafiee1, S. Shahebrahimi, M. Feyz1 and M. Shaterzadeh. *Optimization of synthesis and characterization of nanosilica produced from rice husk (a common waste material)*, International Nano Letters, 2012, 2(29), 8 pages.

[25]. A. M. B. Mahfooz and M. R. Alammari. *The Use of Fourier Transform Infra-Red (FTIR) Spectroscopic Analysis and Cell Viability Assay to Assess Pre-polymerized CAD\CAM Acrylic Resin Denture Base Materials*. Int. J. Pharm. Res. Allied Sci., 2018, 7(2), 111-118.❖

TẠP CHÍ CỦA HỘI HÓA HỌC VIỆT NAM

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* Tạp chí xuất bản hàng quý,
phát hành vào các tháng 3, 6, 9 và 12.

Giá: 200.000 đồng

Trong số này:

3B(71)/9-2024

3 Design and synthesis of some novel amino acid derivatives containing benzo[*d*]thiazole

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Nguyen Cong Thai Son, Le My Lam Thuyen, Pham Nguyen Kim Tuyen, Huynh Bui Linh Chi, Phan Nhat Minh, Nguyen Diep Xuan Ky, Bui Trong Dat, Huynh Thi Kim Chi, Mai Dinh Tri, Dang Van Son, Nguyen Kim Phi Phung, Nguyen Tan Phat

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