



HỘI KHOA HỌC KỸ THUẬT PHÂN TÍCH HÓA, LÝ VÀ SINH HỌC VIỆT NAM  
VIETNAM ANALYTICAL SCIENCES SOCIETY

ISSN - 0868 - 3224

Tạp chí  
**PHÂN TÍCH HÓA , LÝ VÀ SINH HỌC**  
*Journal of Analytical Sciences*

TẠP CHÍ PHÂN TÍCH HÓA, LÝ VÀ SINH HỌC

Tạp chí  
**PHÂN TÍCH**  
**HÓA , LÝ VÀ SINH HỌC**  
*Journal of Analytical Sciences*

**T - 23**

**Số 4 (Đặc biệt)**

**2018**

**PHÂN TÍCH CHẤT ĐỘC TRONG THỰC PHẨM VÀ MÔI TRƯỜNG**

In 500 cuốn, khổ 19 x 27 cm. Giấy phép xuất bản số 445/GP-BTTTT cấp ngày 24/9/2016.  
Chỉ số: ISSN 0868 - 3224. In xong và nộp lưu chiểu tháng 12 năm 2018

**HA NOI**

**ANALYSIS OF OLEORESIN EXTRACTED FROM GINGER RHIZOMES IN NORTH CENTRAL OF VIETNAM BY LIQUID CHROMATOGRAPHY-MASS SPECTROMETRY (LC-ESI-MS)**

*Đến tòa soạn: 20-05-2018*

**Le Thi My Chau<sup>1,2</sup>, Nguyen Thi Minh Tu<sup>1</sup>, Tran Dinh Thang<sup>2</sup>, Le The Tam<sup>2</sup>**

*<sup>1</sup>Hanoi University of Science and Technology*

*<sup>2</sup>Vinh University*

**SUMMARY**

*The ginger are being used by consumers, and clinical trials using ginger have been carried out to evaluate their anti-inflammatory or anti-emetic properties with consistent results. Chemical standardization of these products is needed for quality control and to facilitate the design of clinical trials and the evaluation of data from these studies. To address this issue, methods based on liquid chromatography-mass spectrometry (LC-ESI-MS) were developed for the detection, characterization and quantitative analysis of gingerol-related compounds in ginger roots/rhizomes. This study of the chemical composition of the oleoresins extracted from *Zingiber cochinchinensis*, *Zingiber gramineum*, *Zingiber zerumbet* and *Zingiber rufopilosium*, collected from north central of Vietnam by LC-ESI-MS. Rhizomes of ginger samples were extracted in ethanol in order to obtain ginger oleoresin. Phenolic compounds, gingerol-related compounds ([4], [6], [8]-gingerol, [6]-shogaol...), are responsible for taste and aroma of ginger were determined by LC-MS method.*

**Keywords:** *oleoresin, (6)-gingerol, (6)-shogaol, LC-MS, Z. cochinchinensis, Z. gramineum, Z. zerumbet, Z. rufopilosium.*

**1. INTRODUCTION**

The genus *Zingiber* (*Zingiberaceae* family), which has about 150 species distributed in tropical forest (much of the Southeast Asia, China, India...) and throughout the Islands in the Pacific. In Vietnam, the genus is diverse with about

10 endemic species. They contained essential oils and oleoresins which are used as medicinal drugs, popular spices and raw materials in food, pharmaceutical industry etc...<sup>[9, 4, 3]</sup>. The ginger rhizomes are being used by consumers, and clinical trials using ginger have been carried out

to evaluate their anti-inflammatory or anti-emetic properties with inconsistent results. Chemical standardization of these products is needed for quality control and to facilitate the design of clinical trials and the evaluation of data from these studies. To address this issue, methods based on liquid chromatography-mass spectrometry (LC-ESI-MS) were developed for the detection, characterization and quantitative analysis of gingerol-related compounds in ginger rhizomes.

The ginger rhizomes or its extracts have been commonly used in medicine, because of their wide scope of biological effects-confirmed both in various *in vitro* models and in clinical trials. The plant has been found to show strong antiemetic activity and is now used to treat motion sickness, morning sickness, and post-chemotherapy nausea<sup>[2]</sup>.

Moreover, its analgesic and painkilling properties have been applied in pharmacotherapeutical strategies in the treatment of osteoarthritis due to the marked anti-inflammatory properties of the plant. The confirmed antimicrobial action of the rhizomes (including antibacterial, antiviral, antifungal, and antiparasitic activity) justify its traditional use in cold treatment [8, 2]. The active compounds from ginger rhizomes inhibit platelet aggregation and have a strong vasodilatory effect, which decreases blood pressure and improves blood circulation. Some studies suggest that ginger may be a potential drug in the treatment of diabetes and hypercholesterolemia because of its hypoglycemic and hypolipidemic

properties. Many reports provide information on ginger antineoplastic properties in the treatment of skin, breast, brain, or liver cancer. The two major groups of active compounds from ginger, which are responsible for most of the biological actions of this plant, are polyphenols (gingerols, shogaols, and paradols) and volatiles such as zingiberole, zingiberone, and zingiberene<sup>[5, 7, 12]</sup>.

The chemical composition of *Z. cochinchinensis*, *Z. gramineum*, *Z. zerumbet*, *Z. rufopilosium* rhizomes cultivated on ecological plantations in north central region of Viet Nam. The wide-ranging pharmacological applications of ginger and the increasing consumption of the spice encouraged the authors to perform these studies on the chemical composition of ginger rhizomes, as there are no data in the literature on the active components or element content of ginger grown on North Central region of Vietnam.

## 2. MATERIALS AND METHODS

### 2.1. Plant materials and Sample preparation

Fresh ginger rhizomes (*Z. cochinchinensis*, *Z. gramineum*, *Z. zerumbet*, *Z. rufopilosium*) were collected from north central region of Viet Nam and identified by Dr. Do Ngoc Dai, Nghe an college of economics. The voucher specimens were deposited at the Botany Museum, Institute of Ecology and Biological Resource, Viet Nam Academy of Science and Technology.

100 g ginger rhizomes dried was extracted with ethanol 96% (500 ml x 3) under the following conditions: 16 hours, at normal

temperature and pressure.

## 2.2. LC-ESI-MS analysis

The LC-MS system, 1200 series (Agilent Technology, Santa Clara, CA, USA) equipped with an autosampler Syringe (kdScientifit, USA), a degasser, a ion multichannel detector, and a binary pump was used for chromatographic separation. A microQTOF-QII (broker Daltonic, Germany) mass spectrometer was applied for the identification and determination of gingerols and shogaols in the obtained extracts. The injection volume was 200  $\mu$ L/hour of each standard and extract. The analytes were separated on a ACE3-C<sub>18</sub> column from Agilent Technology (dimension: 150 mm x 4.6 mm, dp = 3.5  $\mu$ m) in a flow rate of 0.3 mL/min for 40 min. The mobile phase consisted of a combination of solvent A (0.1% formic acid) and solvent B (acetonitrile + 0.1% formic acid). The gradient elution was as follows: t = 0 min, 10% B; t = 15 min, 100% B; t = 30 min, 100% B; t = 31 min, 10% B; t = 40 min, 10% B. The photodiode detector continuously recorded the chromatograms in the range of absorbance from 190 to 500 nm. Mass spectra were simultaneously acquired using ESI in positive ionization modes with a capillary voltage of 4500 V. The mass spectra were recorded in the *m/z* range of 50 to 3000 *m/z*. The gas temperature and drying gas flow were 200°C and 9.0 L/min. The skimmer and fragmentation voltages were set at -500 and 4500 V, respectively. The nebulization pressure was 1.5 bar. The MS/MS spectra were recorded for the two most intensive peaks each time.

Three selected gingerols, two shogaols and five gingerdiols present in the extracts were determined qualitatively in the ethanolic rhizome extract based on their fragmentation spectra, the scientific literature, and retention times. A quantitative analysis of the selected phenolics was performed in accordance with the calibration curves of two standards<sup>[12]</sup>.

## 3. RESULTS AND DISCUSSION

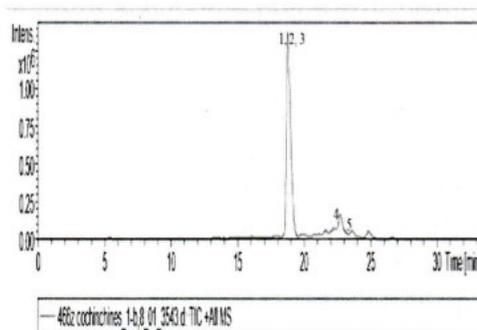


Figure 1. LC/MS analysis of *Z. cochinchinensis* rhizomes extract

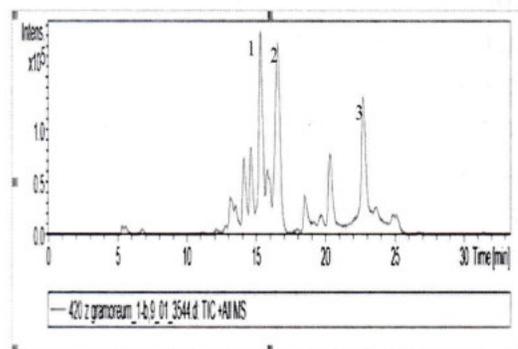


Figure 2. LC/MS analysis of *Z. gramineum* rhizomes extract

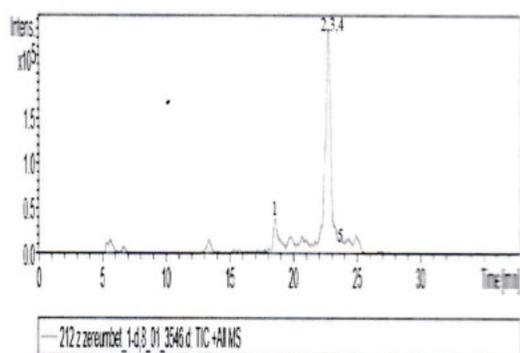


Figure 3. LC/MS analysis of *Z. zerumbet* rhizomes extract

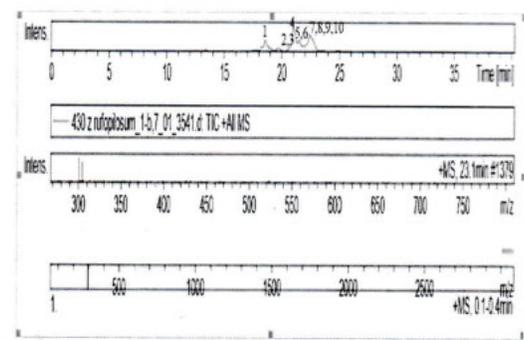


Figure 4. LC/MS analysis of *Z. rufopilosum* rhizomes extract

Crude ethanol extracts, produced from fresh-dried ginger rhizomes (*Z. cochinchinensis*, *Z. gramineum*, *Z. zerumbet*, *Z. rufopilosum*), were used directly for LC/ESI-MS/MS analyses. As shown in Figure 1, positive ionization ESI-MS was used to detect gingerol-related compounds. (Figure 1, 2, 3, 4 and Table 1)

Table 1. Chromatographic and mass spectral characteristics of gingerol-related compounds detected by LC-ESI-MS in extracts from ginger rhizomes

Sample	tR (min)	Positive ESI(+) ESI-MS (m/z)	Compound name	Area Frac. %
(1)	18,7	365,1025 ([M + H] <sup>+</sup> )	Me-[10]-Gingerdiol	5,2
	18,8	343,1215 ([M + H] <sup>+</sup> )	Undetermined	45,7
	18,8	707,2101 ([M + H] <sup>+</sup> )	Undetermined	26,3
	22,5	317,2116 ([M + H] <sup>+</sup> )	1-Dehydro-[8]-Gingerdione	2,1
	22,7	301,1470 ([M + H] <sup>+</sup> )	OAc-[4]-Gingerol	6,2

(2)	15,3	287,0636 ([M + H] <sup>+</sup> )	Undetermined	15,8
	16,6	517,1389 ([M + H] <sup>+</sup> )	Undetermined	9,4
	22,7	301,1489 ([M + H] <sup>+</sup> )	OAc-[4]-Gingerol	12,3
(3)	18,5	274,2808 ([M + H] <sup>+</sup> )	6-Shogaol	7,6
	22,5	241,1646 ([M + H] <sup>+</sup> )	Undetermined	5,6
	22,5	219,1837 ([M + H] <sup>+</sup> )	Undetermined	15,6
	22,7	301,1502 ([M + H] <sup>+</sup> )	OAc-[4]-Gingerol	43,4
	23,3	425,2193 ([M + H] <sup>+</sup> )	Undetermined	2,1
(4)	18,5	274,2764 ([M + H] <sup>+</sup> )	6-Shogaol	2,2
	20,7	688,3993 ([M + H] <sup>+</sup> )	Undetermined	2,2
	20,9	375,2125 ([M + H] <sup>+</sup> )	1-Dehydro-[12]-gingerdione	3,3
	21,0	277,1829 ([M + H] <sup>+</sup> )	[6]-Shogaol	9,4
	21,1	299,1638 ([M + H] <sup>+</sup> )	Undetermined	12,8
	21,5	403,2074 ([M + H] <sup>+</sup> )	1-(4-hydroxy-3-methoxyphenyl)-2-nonadecen-1-one	8,1
	21,9	291,1620 ([M + H] <sup>+</sup> )	1-Dehydro-[6]-Gingerdione	3,4
	22,3	304,3011 ([M + H] <sup>+</sup> )	Undetermined	9,8
	22,4	417,2226 ([M + H] <sup>+</sup> )	1-(3,4-dimethoxyphenyl)-2-Nonadecen-1-one	7,0
	22,7	301,1428 ([M + H] <sup>+</sup> )	OAc-[4]-Gingerol	6,9

Note: (1)-*Z. cochinchinensis*, (2)-*Z. gramineum*, (3)-*Z. zerumbet*, (4)-*Z. rufopilosium*

Spectrometric analysis of the obtained ethanol extracts revealed the presence of the five major phenolic compounds in ginger rhizomes OAc-[4]-gingerol, 8-gingerol, 6-gingerdiol, 6-shogaol, 7-gingerdiol. In addition, another the CID (collision induced dissociation). The ginger spices have different compounds (Table 1).

The application of an optimized LC method, all major phenolic constituents were well separated on a chromatographic column. The fragmentation patterns of all the phenolic compounds listed above were carefully compared with those presented in the scientific literature and are presented in the Figure 1 under application of higher collision energies in the LC-ESI-Q-TOF-MS analysis provided a lower intensity of MS/MS fragments and the loss of the molecular ion peak, which made the identification of compounds more difficult.

The major compound present in the highest amount was OAc-[4]-gingerol in both samples *Z. zerumbet* and *Z. gramineum*. The content of (6)-gingerol was higher compared to that of different cultivars of fresh Australian ginger determined by Wohlmuth et al<sup>[11]</sup> and in fresh Japanese ginger<sup>[12]</sup>. The large concentration of [6]-gingerdiol and [6]-shogaol may also show important health benefits, as this compound has been shown to have strong anticancer properties than fresh plant material<sup>[12]</sup>.

The results of the analysis revealed that the components of incense and gingival composition contained in ginger oleoresin were suited to the research results of other authors. Besides that, different ginger species, there is a relative difference in some components and amounts, possibly due to differences in study species, growth conditions, growth habitats, and the time of sample collection.

#### 4. CONCLUSIONS

LC-ESI-MS analysis of the obtained ethanolic extract revealed that the main

phenolic compound was OAc-[4]-gingerol, [6]-gingerol, [6]-gingerdiol and [6]-shogaol which is characteristic of fresh rhizomes and is responsible for their taste and aroma. Moreover, high amounts of (6)-shogaol were determined, which is interesting because this phenolic compound usually occurs in old or processed material.

Gingerol-related compounds, were identified in ethanol crude extracts from fresh-dried ginger rhizomes by LC/ESI-MS/MS coupled to diode array detection. Interestingly, many of the identified compounds were only detected by the MS detector, therefore, suggesting that the LC/MS analysis is not only more specific, but also more sensitive than diode array analysis for this group of compounds [1, 10].

#### REFERENCES

1. Abdul A.B.H., A.-Z. A. S., Tailan N.D., Wahab S.I.A., Zain Z.N.M., Ruslay S. and Syam M.M. "Anticancer activity of natural compound (zerumbone) extracted from *Zingiber zerumbet* in human HeLa cervical cancer cells." *Int. J. Pharmacol* 4(3): (2008)160-168.
2. Ahouannou, C. J., Y.; Lip , B.; Lallemand. "Characterisation and modelisation of drying of three tropical product: cassava, ginger and okros." *Sciences des Aliments* 20 (4/5): (2000) 431-432.
3. Binh, N. Q. "Hình thái của họ Gừng (*Zingiberaceae* Lindl) ở Việt Nam và các đặc điểm nhận biết nhanh ngoài thiên nhiên." Tuyển tập báo cáo Hội nghị Sinh thái và Tài nguyên sinh vật lần thứ 3, 22/10/2009, Viện ST&TNSV-Viện

KH&CN Việt Nam.

4. Binh, N. Q. Nghiên cứu phân loại họ gừng - Zingiberaceae Lindl. ở Việt Nam. Institute of ecology and biological resources, Ha Noi (2011).

5. Do Ngoc Dai, T. D. T., Le Thi My Chau and Isiaka A. Ogunwande. "Chemical constituents of the root essential oils of *Zingiber rubens* Roxb., and *Zingiber zerumbet* (L.) Smith." *American Journal of Plant Sciences* 4 (2013) 7 - 102.

6. El-Ghorab A. H., N. M., Anjum F. M., Hussain S. and Nadeem M. "A comparative study on chemical composition and antioxidant activity of ginger (*Zingiber officinale*) and cumin (*Cuminumcyminum*)". *J. Agric. Food Chem* 58 (14): (2010) 8231-8237

7. Hongliang Jiang, A. M. S., Barbara N. Timemermann and Divid R. Giang. "Characterization of gingerol-related compounds in ginger rhizome (*Zingiber officinale* Roscoe) by high-performance liquid chromatography/electrospray ionization mass spectrometry". *Rapid Communications in Mass Spectrometry* 19: (2005) 2957-2964

8. Kandiah, M. S. M. "Extraction of ginger

rhizome: kinetic studies with acetone". *International Journal of Food Science and Technology* 24: (1989) 589-600

9. Loi D. T., Ed. *Medical Plants and Blister packs*. Ha Noi, Science and Technics Publishing House (1999)

10. Shim S. K., Choi D. S., Kwon Y. B. and Kwon J. "Anti-inflammatory effects of [6]-shogaol: Potential roles of HDAC inhibition and HSP70 induction". *Food Chem. Toxicol.* 49(11): (2011) 2734-2740

11. Wohlmut, H. L., D. N. Smith, M. K. Myers, S. P. "Gingerol content of diploid tetraploid clones of ginger (*Zingiber officinale* Roscoe)". *Jour. Agric. Food Chem* 53: (2005) 5772-5778

12. Wojciech Koch, W. K. K., Zbigniew Marzec, Elwira Kasperek, Lucyna Wyszogrodzka-Koma, Wojciech Szwer, and Yoshinori Asakawa. "Application of Chromatographic and Spectroscopic Methods towards the Quality Assessment of Ginger (*Zingiber officinale*) rhizomes from Ecological Plantations". *International Journal of Molecular Sciences* 18: (2017) 452-467

- imprinted polymer based on graphene/poly(1,8 diaminonaphthalene) modified electrode  
*Trương Thị Hồng Ngọc, Lê Quân, Vũ Văn Trọng, Bùi Thanh Duy, Nguyễn Lê Huy, Nguyễn Văn Anh, Đỗ Phúc Quân, Nguyễn Tuấn Dung*
24. Tổng hợp vật liệu tổ hợp nano graphene oxit – titan dioxit (GO-TiO<sub>2</sub>) bằng phương pháp thủy nhiệt và phân hủy phenol dưới ánh sáng khả kiến 183  
 Hydrothermal synthesis of graphene OXIDE-TiO<sub>2</sub> nano composites for photodegradation of phenol under visible light  
*Trần Minh Đức, Đặng Xuân Hiến*
25. Mức độ tồn lưu chất da cam/dioxin ở huyện a lưới, tỉnh Thừa Thiên Huế 191  
*Lê Thị Hải Lê, Nguyễn Hùng Minh, Nguyễn Văn Quân*
26. Kiểm kê phát thải ô nhiễm không khí do hoạt động giao thông ở hà nội và đánh giá hiệu quả từ các chính sách giảm thiểu 198  
*Nguyễn Duy Tùng, Nguyễn Thị Thu, Kim Minh Thúy, Trương An Hà, Nguyễn Ngọc Tùng, Nguyễn Quang Trung*
27. Ảnh hưởng của thuốc trừ sâu fenitrothion đến khả năng sinh sản của rotifer brachionus calyciflorus 206  
 Effects of pesticide fenitrothion to rotifer brachionus calyciflorus' reproductivite  
*Nguyễn Xuân Tòng, Trần Thị Thu Hương, Mai Hương, Dương Thị Thủy*
28. Hàm lượng kim loại nặng (Cd, Pb, Zn) trong một số động vật hai mảnh tại vùng biển ven bờ quy nhơn, tỉnh bình định 214  
*Lê Thu Thủy, Lê Thị Hải Lê, Nguyễn Thị Thục Anh, Lương Ngân Hà, Nguyễn Thanh Thảo*
29. Nghiên cứu hiệu quả xử lý chất thải gia cầm bằng phương pháp vermicompost để giảm thiểu ô nhiễm môi trường 220  
 Study the effectiveness of treatment chicken manure by vermicomposting to reduce environmental pollution  
*Nguyễn Minh Khánh, Nguyễn Tam Minh Hòa, Nguyễn Tấn Đức, Nguyễn Ngọc Phi, Vũ Thùy Dương, Nguyễn Thị Hạnh Nguyên*
30. Ước tính phát thải khí nhà kính và các chất gây ô nhiễm không khí từ hoạt động nông nghiệp trong khu vực hà nội và đánh giá các kịch bản thay thế 226  
*Kim Minh Thúy, Nguyễn Duy Tùng, Nguyễn Thị Thu, Trương An Hà, Nguyễn Ngọc Tùng, Nguyễn Quang Trung*
31. Dư lượng hóa chất trừ cỏ (2,4-D; 2,4,5-T) trong môi trường nước và trầm tích biển ven bờ phía Bắc Việt Nam 236  
 Residues of herbicides (2,4-D; 2,4,5-T) in coastal water and sediments environment in the northern part of Vietnam  
*Lê Văn Nam, Dương Thanh Nghị, Nguyễn Thị Mai Lựu*
32. Đặc tính von – ampe hòa tan của Pb(II) trên điện cực cacbon thủy tinh biến tính bởi platin nano dạng hạt 241

- Characteristics of stripping voltammetry of lead on platinum nanoparticles modified glassy carbon electrode  
*Nguyễn Thị Liễu, Cao Văn Hoàng, Nguyễn Thị Thùy Linh, Bùi Văn Hào, Lê Trường Giang*
33. Khảo sát mức độ ô nhiễm vi sinh vật trong môi trường nước ven biển nuôi trồng thủy sản thuộc địa phận huyện Giao Thủy, tỉnh Nam Định 248  
Investigation of bacterial density in aquacultural water in coastal zone of the Giao Thuy district, Nam Dinh province 257  
*Lê Như Đa, Lê Thị Phương Quỳnh*
34. Chế tạo cảm biến điện hoá xác định Pb(II) trên cơ sở điện cực màng composit graphen/poly(1,5-diaminonaphtalen) 263  
*Đặng Thị Thu Huyền, Nguyễn Lê Huy, Nguyễn Tuấn Dung, Trần Đại Lâm*
35. Điều chế vật liệu hấp phụ từ bã mía bằng phương pháp hoạt hóa hóa học và ứng dụng xử lý nước thải tại bình định. 272  
Preparation of adsorption materials from sugarcane bagasse by chemical activation method and applicability treatment wastewater in binh định  
*Nguyễn Thị Liễu, Nguyễn Thị Thùy Mỹ, Đặng Thị Tố Nữ, Cao Văn Hoàng, Bùi Xuân Tỉnh*
36. Nghiên cứu chế tạo vật liệu hấp phụ từ vỏ lạc bằng phương pháp hoạt hóa hóa học để ứng dụng hấp phụ Pb<sup>2+</sup> từ dung dịch nước 281  
Study on fabrication adsorption material from peanut shell by chemical activation method to apply on Pb<sup>2+</sup> adsorption from aqueous solution  
*Nguyễn Thị Liễu\*, Hồ Mai Hương, Trần Thị Thu Hiền, Bùi Xuân Tỉnh, Đào Hải Yến*
37. Phân cấp vùng rủi ro ô nhiễm môi trường biển và hải đảo một số vùng biển thuộc quần đảo Trường Sa 289  
*ThS. Vũ Thị Quỳnh Chi, ThS. Nguyễn Thị Ngọc Anh*
38. Nghiên cứu quy trình xác định một số kim loại trong nước biển xa bờ tại một số vùng biển Việt Nam bằng khối phổ phát xạ plasma cảm ứng cao tần (ICP-MS) sau khi tách nền muối bằng phức dithiocarbamat 295  
*Ths. Thân Văn Hậu, Ths. Vũ Thị Quỳnh Chi*
39. Xử lý phenol trong nước thải luyện cốc bằng ozon hóa kết hợp với đá ong biến tính Removal phenol in coke wastewater by ozone combine with modified laterit 305  
*Hoàng Hải Linh, Nguyễn Quang Trung, Nguyễn Thanh Thảo*
40. Phát triển cảm biến miễn dịch điện hóa trên cơ sở kháng thể IGY chiết xuất từ trứng gà ứng dụng trong phát hiện nhanh virus newcastle 312  
*Trần Thị Luyến, Trần Quang Thịnh, Trần Vĩnh Hoàng, Mai Anh Tuấn*
41. Phân tích trực tiếp các chất diệt cỏ họ Glyphosate bằng phương pháp LC-MS/MS

- Phần 1. Tối ưu hóa các điều kiện tách và phân tích  
*Mai Thị Nga Linh, Vũ Cẩm Tú, Đỗ Hồng Quân, Nguyễn Ngọc Hưng, Nguyễn Lan Anh, Nguyễn Mạnh Hà, Từ Bình Minh, Chu Đình Bình*
42. Tối ưu hóa quá trình phân tích Pb(II) trên điện cực PTNFS/GC sử dụng phương pháp đáp ứng bề mặt 322  
 Optimization of Pb(II) analysis process on the PTNFS/GC  
*Nguyễn Thị Liễu, Cao Văn Hoàng, Phạm Quốc Trung, Lê Trường Giang*
43. Đánh giá mức độ phát thải và đặc trưng đồng loại của các chất polyclo biphenyl tương tự dioxin (DL-PCBs) trong khí thải của một số cơ sở công nghiệp ở miền bắc Việt Nam 332  
**Assessment of emission and congener profiles of dioxin-like polychlorinated biphenyls (DL-PCBs) in stack gas samples from some industrial plants in northern Vietnam**  
*Phạm Thị Ngọc Mai, Đào Thị Nhung, Nghiêm Xuân Trường, Hoàng Quốc Anh, Từ Bình Minh, Đặng Minh Hương Giang, Nguyễn Mạnh Hà, Nguyễn Thuý Ngọc*
44. Phát hiện tinh thể tím bằng phương pháp tán xạ Raman tăng cường bề mặt 338  
 Detection of crystal violet by surface-enhanced Raman  
*Cao Tuấn Anh, Hoàng Thị Thu Hải, Kiều Ngọc Minh, Lương Trúc Quỳnh Ngân, Đào Trần Cao, Lê Văn Vũ, Vũ Mạnh Hùng, Trịnh Phi Hiệp và Nguyễn Lê Phương*
45. Analysis of oleoresin extracted from ginger rhizomes in north central of Vietnam by liquid chromatography-mass spectrometry (LC-ESI-MS) 345  
*Le Thi My Chau, Nguyen Thi Minh Tu, Tran Dinh Thang, Le The Tam*
46. A simple and environment-friendly HPLC method for monitoring paraquat strongly adsorbed on soils 352  
*Sadao Matsuzawa, MioriUno, Nguyen Tien Đạt, Nguyen Quang Trung*
47. Characteristics of waste lubricants as alternative fuels in Vietnam cement plants 362  
*Hoang Quoc Trong, Pham Gia Dien*
48. Synthesis of green mof-based photocatalyst for degradation of organic dyes under sunlight irradiation 369  
*Phạm Trường Giang, Đinh Xuân Việt, Lê Thị Trang, Trần Thị Thu Hiền, Nguyễn Xuân Trường, Trần Thượng Quảng*
49. **An electrochemical sensor based on poly(p-aminophenylacetic acid) film modified glassy carbon electrode for auramine o detection** 376  
*Phung Thi Tinh, Nguyen Van Quynh, Nguyen Quang Trung, Tran Quang Thuan*
50. Research on design and manufacturing a treatment equipment of clinic wastewater using modified eco-bio-block material 392