# How to Write A Scientific Research Paper

# أسس كتابة البحث العلمي


Dr. Mohamed El-Newehy

*Associate Professor*

Department of Chemistry - College of Science

King Saud University

Riyadh 11451 – Saudi Arabia

E-mail: melnewehy@ksu.edu.sa

# عناصر العرض

- ما هو البحث العلمي
- المستويات الأساسية للبحوث
- خطوات كتابة البحث العلمي
- أجزاء البحث الرئيسية

# ما هو البحث العلمي

البحث العلمي هو جهد دراسي منهجي يهدف الى حل مشكلة معينة في تخصص ما، بحيث يقدم مساهمة حقيقية لهذا التخصص.

# المستويات الأساسية للبحوث:

## تقسم المستويات الأساسية للبحوث الى ثلاثة أصناف:

1) **بحوث قصيرة على مستوى الدراسة الجامعية الأولى** (البكالوريوس)

هدفها هو:

- أن يتعمق الطالب في دراسة موضوع معين، وليس الحصول على معلومات جديدة
- أن يتدرب على استخدام مصادر المعلومات المطبوعة وغير المطبوعة ، ثم تحليلها والوصول الى نتائج .
- عادة يكون هذا البحث قصيراً من 10 – 40 صفحة .

2) **بحوث متقدمة على مستوى رسالة الماجستير** وتسمى (Master Thesis)

وهي عبارة عن بحث طويل نوعاً ما يساهم في إضافة شيء جديد في موضوع الإختصاص .

3) **بحوث متقدمة على مستوى رسالة الدكتوراة**

(Doctoral Dissertation)

وهو بحث شامل ومتكامل لنيل درجة جامعية.

يشترط به أن يكون جديداً وأصيلاً وأن يساهم في إضافة شيئاً جديداً للعلم .

**نشر علمي في صورة**

- **بحث أصيل** - **براءة إختراع** - **مقال إستعراضي**

# خطوات كتابة البحث العلمي:

1) **اختيار موضوع البحث**

- في هذه الخطوة يكون الباحث حرا في اختيار أي موضوع للاجابة عن جميع الأسئلة التي تخطر على باله.
- أغلبية البحوث إنما تخطئ الطريق من نقطة الانطلاق بسبب
  - لكون الأسئلة المطروحة تكون إما بسيطة جدا أو فضفاضة جدا.
  - لكون مجال البحث المختار يكون إما محدد بشكل رديء.
- ولذلك يجب على الباحث أن يفكر ملياً في اختيار العناصر التي تعتبر مبادئ أساسية للبحث وهي:
  - موضوع البحث
  - الإطار المرجعي (أو النظري) للبحث
  - منهج البحث
  - صياغة الإشكالية.

2) **مراجعة الادبيات**

هنا تعني مراجعة النظريات والدراسات السابقة ذات الصلة بالموضوع الذي وقع عليه الاختيار والذي يصبح موقع اهتمامنا وانشغالنا.

و هي من اهم خطوات البحث العلمي حيث من خلالها نقدم تبرير بحثنا أي ما هو الجديد الذي سنقدمه او نضيفه على المعرفة وتحدي الاطار المرجعي او النظري الذي سيعتمد ، بالاضافة الى التحديد الدقيق لاشكالية البحث .

# خطوات كتابة البحث العلمي:

3) **تحديد الموضوع بشكله النهائي**
صياغة المشكلة في عبارات واضحه مفهومة ومحددة تعبر عن المضمون.

4) **تدوين مصادر المعلومات الأساسية**
تدوين النقاط الهامة سواء كان ذلك (أ) عن طريق ألاقتباس (ب) أو تلخيص الأفكار مع ذكر المصدر باستمرار

5) **تجميع وتنظيم الأفكار**
بعد تجميع ما يكفي من المعلومات حول موضوع البحث. بعد ذلك يصبح الباحث ملماً نوعاً ما بنواحي موضوعه وبناءً عليه يضع خطة أو هيكلاً عاماً مؤقتاً لبحثه، يراعي فيه الترتيب المنطقي المتسلسل والترابط بين أجزائه ويختار له عنواناً مختصراً واضحاً، على أن تكون هذه الخطة خاضعة للتعديل من حذف وإضافة فيما بعد . ثم يبدأ بكتابة البحث.

أجزاء البحث الرئيسة :

# Origins of Scientific Writing

*Question from*

| | |
|---|---|
| - *What* question (problem) was studied? | *Answer* = Introduction |
| - *How* was the problem studied? | *Answer* = Methods |
| - *What* were the results? | *Answer* = Results |
| - *What* do the findings mean? | *Answer* = Discussion |

# Elements of The Scientific Research Paper

## A scientific original article usually consists of the following elements:

- **Title - descriptive and concise**
- **Abstract –a short summary of the article**
- **Introduction –background information, aim and problem statements**
- **Methodology –so that the reader can follow and repeat the research process**
- **Result - presentation of the research results**
- **Discussion – interpretation and evaluation of the results.**
- **Conclusions and relation to previous research**
- **References - all documents that the author has referred to must be listed.**

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# Microwave Synthesis of Copolymers Based on Itaconic Acid Moiety and Their Utility for Scavenging of Copper (II) and Lead (II)

MOHAMED H. EL-NEWEHY[1,2,3,*], SAMEH M. OSMA and AYMAN EL-FAHAM[1,7,*]

[1] *Department of Chemistry, College of Science, King Saud Universi*
[2] *Petrochemicals Research Chair, Department of Chemistry, Colleg Saudi Arabia*
[3] *Department of Chemistry, Faculty of Science, Tanta University, T*
[4] *Advanced Materials Research Chair, Department of Chemistry, C 11451, Saudi Arabia*
[5] *Department of Chemistry, College of Science, Taif University, Tai*
[6] *Department of Chemistry, Faculty of Science, Port Said Universit*
[7] *Department of Chemistry, Faculty of Science, Alexandria Univers*

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We report here the preparation of the two copolymers, itaconic a ratios using microwave irradiation in the presence of azobisisobu prepared copolymers were characterized by different techniques; stability property of the prepared copolymers correlated with th increased, the crystallinity of the copolymer decreases. The itacon in alkaline media for Cu (II) and Pb (II). The chelation behavior thermogravimetric analysis (TGA), and differential scanning calo

**Keywords:** Microwave synthesis, itaconic acid, copolymerization,

## 1 Introduction

The microwave technique is safe, fast and gives high yield of the products with high purity in an optimum time, comparing to the conventional method. Recently, there has been growing interest in applying microwave irradiation to synthetic organic chemistry, (1–8) sample preparation for analysis, (9) extraction of natural products from plants, (10) waste treatment, (11) and polymer synthesis (12–15).

The design of suitable polymeric materials is an increasingly important research area due to demands for

*Address correspondence to: Mohamed H. El-Newehy and Ayman El-Faham, Department of Chemistry, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia. E-mail: melnewehy@hotmail.com and aelfaham@ksu.edu.sa

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**Table 1.** Yield (%) of MMA/IA and AA/IA copolymers using microwave irradiation

| *Method* | *Copolymer code* | *MMA/IA Ratio* | *MMA(mmol)* | *IAA(mmol)* | *Yield(%)* |
|---|---|---|---|---|---|
| Conventional | PMIAA 3 | 10:4 | 20 | | |
| Microwave | PMIAA 10 | 10:1 | 100 | | |
| | PMIAA 11 | 10:2 | 100 | | |
| | PMIAA 12 | 10:4 | 50 | | |
| Method | Copolymer code | AA/IA Ratio | AA(mmo | | |
| Microwave | PAIAA 13 | 10:1 | 100 | | |
| | PAIAA 14 | 10:2 | 100 | | |
| | PAIAA 15 | 10:4 | 100 | | |

an ecofriendly method for preparation of the desired copolymers. The work also describes the ability of the two copolymers for scavenging of heavy metal such as Cu (II) and Pb (II).

## 2 Experimental

### 2.1 Materials

Itaconic acid (IAA), acrylamide (AA) and methyl methacrylate (MMA) were supplied from Sigma-Aldrich. *N,N'*-Azobisisobutyronitrile (AIBN) was supplied from Hanover and was re-crystallized from absolute ethanol before use. Lead (II) nitrate and copper (II) sulfate were supplied from Fluka. All solvents were dried before use.

### 2.2 Measurements

The microwave irradiation employing a multimode reactor (Synthos 3000, Anton Paar GmbH, and 1400 W maximum magnetron) was used to prepare the copolymers. Fourier transform infrared spectroscopy (FT-IR) spectra were recorded on a Nicolet 560 Magna Spectrometer. Thermal properties of the copolymers and their complexes were examined using thermogravimetric analysis (TGA) under nitrogen, in the temperature range 30–800°C with a heating rate of 10°C/min, and differential scanning calorimetery (DSC) which was carried out using TA-Q500 in which Specimens of (5–10 mg) were encapsulated in aluminum pans and were heated or cooled between −25°C and 400°C under dry nitrogen atmosphere with heating rate of 10°C /min. Elemental microanalysis tests were performed on (Perkin-Elmer, 24003 series), the sample was burned in an excess of oxygen, and various traps collect the combustion products-carbon dioxide, water, and nitric oxide. The masses of these combustion products have been used to calculate the composition of the sample. The measurements of lead (Pb) and Copper (Cu) were performed using Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES), (iCAP 6000 SERIES). All the samples were performed in triplicate and the results reported



cooling was accomplished by a fan (5 min). The final product poly(methyl methacrylate-*co*-itaconic aicd) –PMIAA or poly(acrylamide-co-itaconic aicd)–PAIAA was washed with diethyl ether, and then dried in oven under vacuum at 40°C for 24 h.

### 2.5 Copolymers Complexes of $Cu^{2+}$ and $Pb^{2+}$

For all preparations, doubly distilled water was employed as a solvent. All used reagents were of analytical grade and were employed without further purifications. Copper (II) sulphate and Pb (II) nitrate (1 mmol) were dissolved in 20 mL of water and then the prepared solutions were slowly added to 25 $cm^3$ of an aqueous solution with 2 mmol of each itaconic acid copolymers with stirring. The pH of each solution was adjusted to 6–8 by addition of ammonium hydroxide. The resulting solutions were heated at 70°C and left to evaporate slowly at room temperature overnight. The obtained precipitate were filtered off, washed with hot water and was dried in oven under vacuum at 70°C.

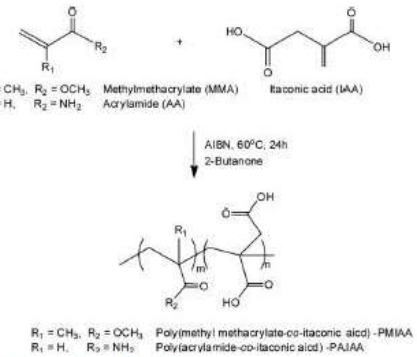
## 3 Results and Discussion

### 3.1 Synthesis of Copolymers

The two copolymers itaconic acid-methyl methacrylate and itaconic acid-acrylamide (PMIAA and PAIAA) with different ratios were prepared using a multimode reactor (Synthos 3000, Aton Paar GmbH, 1400 W maximum magnetron), in the presence of AIBN for 5 min at 140°C and 400W. For comparison study, the copolymer PMIAA 3 (10:4; MMA:IAA) was prepared by conventional method using 2-butanone as a solvent and AIBN as initiator at 60°C, under nitrogen atmosphere for 24 h (Table 1 and Sch. 1). The prepared copolymers were characterized using FT-IR spectrum, TGA, DSC, and microanalysis.

### 3.2 Fourier Transform Infrared Spectroscopy (FT

The FT-IR of the poly(methyl methacrylate-*co*-itaconic aicd)–PMIAA, showed the characteristic a peaks of the acid group and the ester at 3700–3 for the carboxylic hydroxyl group (OH), at 163 the carboxyl carbonyl group (C=O), and at 169 the carbonyl ester (C=O) of methyl methacryla respectively (Fig. 1a). Also, FT-IR for poly(*co*-itaconic aicd)–PAIAA showed similar absor for the acid group, carboxylic hydroxyl group the carbonyl group (C=O), beside the carbo (CONH) for the acrylamide moiety at 1640 cm 3349 $cm^{-1}$ for the NH (Fig. 1b). The IR spectru that, the intensity of the –OH and –C=O of the group was increased as the ratio of IAA increa copolymer.




**Sch. 1.** Copolymerization of itaconic acid with acrylic monomers.



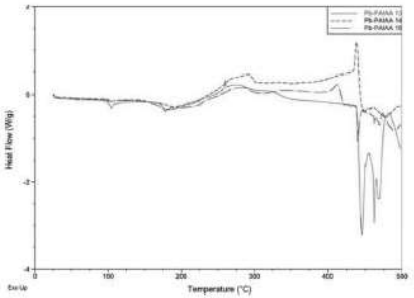



**Fig. 18.** DSC scan of Pb-PAIAA series.

(DSC). The thermogravimetric thermograms showed a similar data to Pb-PMIAA, were obtained for (Pb-PAIAA 13–14), but not for Pb-PAIAA 15, where the copolymer loaded with lead have only a very sharp endothermic peak at 350°C, which is the same like Cu-PAIAA. Thermograms of DSC are shown in (Fig. 18), which shows similar behavior of the copper containing copolymers series.

## 4 Conclusions

In conclusion, we have demonstrated that microwave irradiation could be employed efficiently for the synthesis of two types of copolymers contained methyl methacrylate and acrylamide with different ratios of itaconic acid in short time with high yield and purity. The thermal stability property of the prepared copolymer correlated with the changing of the itaconic acid ratio, as the ratio of itaconic acid increased, the crystallinity of the copolymer decreases.

The itaconic acid-based copolymers also showed a good scavenging behavior in alkaline media for Cu (II) and Pb (II). Thermogravimetric analysis (TGA) and differential scanning calirometry (DSC) showed that the thermal stability of the copolymers increase with increasing the content of Copper metal ($Cu^{2+}$) or Lead metal ($Pb^{2+}$).

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### References

1. Wagner, R. W. (2006) Drug Discov. World, 7: 59–66.
2. Kantesaria, J. L., Cotterill, I. (2000) Curr. Opin. in Drug Discov. and Develop., 3: 454–462.
3. Desai, K. R. (2008) Green Chemistry Microwave Synthesis. First Edition, (Himalaya Publication House, India) 1.
4. Kappe, C. O. (2004) Angew. Chem. Inter. Edition Eng., 43: 6250–6284.
5. Qu, G. R., Wu, J., Wu, Y. Y., Zhang, F., Guo, H. M. (2009) Green Chem., 11: 760–762.
6. Dolzhenko, A. V., Pastorin, G., Dolzhenko, A. V., Chui, W. K. (2009) Tetrahedron Lett., 50: 2124–2128.
7. Al-Hazimi, H. M., El-Faham, A., Ghazali, M., Al-Farhan Kh. (2012) Arab. J. Chem., 5: 285–289.
8. Ghazali, M., El-Faham, A., Abd-Megeed, A., Al-Farhan, Kh. (2012) J. Mol. Struct., 1013: 163–167.
9. Silinski, B., Kurnoyez, C., Gourdenne, A. (1987) Eur. Polym. J., 23: 273–277.
10. Imai, Y., Nemoto, H., Watanabe, S., Kakimoto, M. A. (1996) Polym. J., 28: 256–260.
11. Liu, Y., Sun, X. D., Xie, X. Q., Soola, D. A. (1998) J. Polym. Sci. Polym. Chem., 36: 2653–2665.
12. Sunti, M. A., Jauhari, S., Desai, K. R. (2012) Arch. Appl. Sci. Res., 4: 645–661.
13. Wiesbrock, F., Hoogenboom, R., Schubert, U. S. (2004) Macromol. Rapid Comm., 25: 1739–1764.
14. Hoogenboom, R, Schubert, U. S. (2007) Macromol. Rapid Comm., 28: 368–386.
15. Koopmans, C., Iannelli, M., Kevekp, P., Klink, M., Schmitz, S., Sinnwell, S., Ritter, H. (2006) Tetrahedron, 62: 4709–4714.

Kingdom of Saudi Arabia
King Saud University
College of Science
Chemistry Department

# Synthesis and Characterization of Amine-Terminated Polymers and Their Use as Carriers for Antimicrobial Agents

Submitted in Partial Fulfillment of the Requirements
For
*Master Degree of Science in Polymer Science*
*Department of Chemistry*
*College of Science*
*King Saud University*

*By*

Abdullah Ali Al-Amri

Supervisor: Dr. Mohamed Hassan El-Newehy
Co-Supervisor: Prof. Dr. Salem S. Al-Deyab
Co-Supervisor: Prof. Dr. Hak Yong Kim

1433(H)-2012(G)

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I would like to especially thank ***Dr. Mohamed Hassan El-Newehy***, *Assistant Professor of Organic Chemistry at Department of Chemistry, College of Science, King Saud Uni*... guidance suppo... reviewing critic... this work at Kin...
I would...

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**List of Abbreviations**

| | |
|---|---|
| AN | Acrylonitrile |
| PAN | |
| PEMA | |
| ED | |
| HMDA | |
| PAN-ED | |
| PAN-HMDA | |

***ABSTRACT***

The antimicrobial polymers are materials that have biocidal effect where they can render harmless or exert a controlling effect on any harmful microorganisms such as Gram-positive or... a demand for the a... use of conventiona... prepare and develo...

## 1. INTRODUCTION

### *1.1. Bakcground*

A polym... large molecul... latter case the... polymer mole... in the molecu... *vP*. The relat...

## 2. EXPERIMENTAL

### *2.1. Materials*

All ...
1). All solv...

## 3. RESULTS AND DISCUSSION

The design and applications of antimicrobial polymers is a growing field. The use of antimicrobial... the environment... agents by reduc... the antimicrobia... they are nonvola...

## 4. CONCLUSION

The design and applications of antimicrobial polymers is a growing field. Antim... conve... carrier...
antimi...
emplo...

## 5. REFERENCES

[1] Nicholson, J.W. *Chemistry of Polymers* 2nd ed. (RSC, UK), 1-5, 1997.
[2] Joseph, G. *Reactive & Functional Polymers* **39**, 99–138, 1999.
[3] Kenawy, E.-R.; Worley, S. D.; Broughton.A. R. *Biomacromolecules*, **8**, 1360-1384, 2007.
[4] Bowersock, T. L.; Woodyard, L.; Hamilton A. J.; Deford, J. A. *J. Controll. Release* **31**, 237-243, 1994.
[5] Ikeda, T.; Yamaguchi, H.; Tazuke, S. *J. Antimicrob. Agents Ch.* **26**, 139–144, 1984.

# Title

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## Microwave Synthesis of Copolymers Based on Itaconic Acid Moiety and Their Utility for Scavenging of Copper (II) and Lead (II)

MOHAMED H. EL-NEWEHY[1,2,3,*], SAMEH M. OSMAN[1,4], MOAMEN S. REFAT[5,6], SALEM S. AL-DEYAB[1,2], and AYMAN EL-FAHAM[1,7,*]

[1]*Department of Chemistry, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia*
*...trochemicals Research Chair, Department of Chemistry, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, ...bia*
*...mistry, Faculty of Science, Tanta University, Tanta 31527, Egypt*
*... Chair, Department of Chemistry, College of Science, King Saud University, P.O. ...*

# Title

- **Importance:** read by thousand of people (only few if any will read the full paper).
- **Need** to reach its intended audience.
- **Choice of words.**
- **Order of words**
- **Rule:** fewest possible words that adequately describe the content of the paper
  - Not to short: need for specific title (no general).
  - Not to long: not an abstract.
  - No waste words (study on …., observation on …., ect).
  - No abbreviations.

# How to list the Authors?

- Order of names? Problem (origin of disputes and arguments).
- Authorship
  - Takes the intellectual responsibility of the results being presented.
  - Should have made an important contribution to the study being reported
  - Intellectual input: not easy to measure.
- Corresponding author (reprints address, proofs, …).
- Self contained (published by itself).
- Economy of words (but no abbreviations)
- Your names and date appear below the title.

# Authors

## Microwave Synthesis of Copolymers Based on Itaconic Acid Moiety and Their Utility for Scavenging of Copper (II) and Lead (II)

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[1]*Department of Chemistry, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia*
[2]*Petrochemicals Research Chair, Department of Chemistry, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia*
[3]*Department of Chemistry, Faculty of Science, Tanta University, Tanta 31527, Egypt*
[4]*Advanced Materials Research Chair, Department of Chemistry, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia*
[5]*Department of Chemistry, College of Science, Taif University, Taif 21974, Saudi Arabia*
[6]*Department of Chemistry, Faculty of Science, Port Said University, Port Said, Egypt*
[7]*Department of Chemistry, Faculty of Science, Alexandria University, P. O. Box 246 Ibrahimia, 21321 Alexandria, Egypt*

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Microwave Synthesis of Copolymers Based on Itaconic Acid Moiety and Their Utility for Scavenging of Copper (II) and Lead (II)

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[1] *Department of Chemistry, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia*
[2] *Petrochemicals Research Chair, Department of Chemistry, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia*
[3] *Department of Chemistry, Faculty of Science, Tanta University, Tanta 31527, Egypt*
[4] *Advanced Materials Research Chair, Department of Chemistry, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia*
[5] *Department of Chemistry, College of Science, Taif University, Taif 21974, Saudi Arabia*
[6] *Department of Chemistry, Faculty of Science, Port Said University, Port Said, Egypt*
[7] *Department of Chemistry, Faculty of Science, Alexandria University, P. O. Box 246 Ibrahimia, 21321 Alexandria, Egypt*

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We report here the preparation of the two copolymers, itaconic acid-methyl methacrylate and itaconic acid-acrylamide, in different ratios using microwave irradiation in the presence of azobisisobutyronitrile (AIBN) as initiator and 2-butanone as a solvent. All the prepared copolymers were characterized by different techniques; FT-IR, thermal analysis and elemental microanalysis. The thermal stability property of the prepared copolymers correlated with the changing of the itaconic acid ratio, as the ratio of itaconic acid increased, the crystallinity of the copolymer decreases. The itaconic acid-based copolymers also showed a good scavenging behavior in alkaline media for Cu (II) and Pb (II). The chelation behavior of both Cu (II) and Pb (II) complexes were checked using FT-IR, thermogravimetric analysis (TGA), and differential scanning calorimetry (DSC).

**Keywords:** Microwave synthesis, itaconic acid, copolymerization, metal scavenging, thermal stability

### 1 Introduction

The microwave technique is safe, fast and gives high yield of the products with high purity in an optimum time, comparing to the conventional method. Recently, there has been growing interest in applying microwave irradiation to synthetic organic chemistry, (1–8) sample preparation for analysis, (9) extraction of natural products from plants, (10) waste treatment, (11) and polymer synthesis (12–15).

The design of suitable polymeric materials is an increasingly important research area due to demands for applications in pharmaceutical, agricultural, biomedical, surgical implants, scaffolds for tissue engineering (16–19) and metal chelation (20–24).

Poly(acrylic acid) (PAA) is the simplest analog of weak polyelectrolytes, which can be used as flocculant in water treatment (23, 24). Various types of small molecules such as metal ions are complexed to PAA and its derivatives containing hydrophilic carboxyl groups.

The binding of metal ions to carboxylic acids has been a subject of intense research investigation in view of its various applications, such as from the relevance of metal-carboxylate complexes as model systems for the metalloactive sites in bioinorganic chemistry (25, 26). The structural diversity encountered in metal-carboxylate complexes can be attributed to the versatile bonding behavior of the carboxylate group, which can act as a bidentate ligand or a bridging ligand (27, 28).

Herein, we report the synthesis and characterization of two copolymers itaconic acid-methyl methacrylate and itaconic acid-acrylamide employing microwave irradiation as

*Address correspondence to: Mohamed H. El-Newehy and Ayman El-Faham, Department of Chemistry, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia. E-mail: melnewehy@hotmail.com and aelfaham@ksu.edu.sa

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# Abstract

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We report here the preparation of the two copolymers, itaconic acid-methyl methacrylate and itaconic acid-acrylamide, in different ratios using microwave irradiation in the presence of azobisisobutyronitrile (AIBN) as initiator and 2-butanone as a solvent. All the prepared copolymers were characterized by different techniques; FT-IR, thermal analysis and elemental microanalysis. The thermal stability property of the prepared copolymers correlated with the changing of the itaconic acid ratio, as the ratio of itaconic acid increased, the crystallinity of the copolymer decreases. The itaconic acid-based copolymers also showed a good scavenging behavior in alkaline media for Cu (II) and Pb (II). The chelation behavior of both Cu (II) and Pb (II) complexes were checked using FT-IR, thermogravimetric analysis (TGA), and differential scanning calorimetery (DSC).

**Keywords:** Microwave synthesis, itaconic acid, copolymerization, metal scavenging, thermal stability

## 1 Introduction

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applications in pharmaceutical, agricultural, biomedical, surgical implants, scaffolds for tissue engineering (16- ' and metal chelation (20–24).

# How to prepare the Abstract?

- The abstract = brief summary (250 words).
- Goal = Allows the reader to decide to read or not
- **Structure**
  - State principle objectives and scope.
  - Describe the methodology employed.
  - Summarize the results.
  - State the principal conclusions.
- Past tense because refers to work done.
- No references.
- Self contained (published by itself).
- Economy of words (but no abbreviations)

# Introduction

**The introduction is a brief section (no more than 1 page usually) designed to inform the reader of the relevance of your research and includes a short history that leads to a statement of the problem that is being addressed.**

# Introduction

**Keywords:** Microwave synthesis, itaconic acid, copolymerization

## 1 Introduction

The microwave technique is safe, fast and gives high yield of the products with high purity in an optimum time, comparing to the conventional method. Recently, there has been growing interest in applying microwave irradiation to synthetic organic chemistry, (1–8) sample preparation for analysis, (9) extraction of natural products from plants, (10) waste treatment, (11) and polymer synthesis (12–15).

The design of suitable polymeric materials is an increasingly important research area due to demands for applications in pharmaceutical, agricultural, biomedical, surgical implants, scaffolds for tissue engineering (16–19) and metal chelation (20–24).

Poly(acrylic acid) (PAA) is the simplest analog of weak polyelectrolytes, which can be used as flocculant in water treatment (23, 24). Various types of small molecules such as metal ions are complexed to PAA and its derivatives containing hydrophilic carboxyl groups.

The binding of metal ions to carboxylic acids has been a subject of intense research investigation in view of its various applications, such as from the relevance of metal-carboxylate complexes as model systems for the metalloactive sites in bioinorganic chemistry (25, 26). The structural diversity encountered in metal-carboxylate complexes can be attributed to the versatile bonding behavior of the carboxylate group, which can act as a bidentate ligand or a bridging ligand (27, 28).

Herein, we report the synthesis and characterization of two copolymers itaconic acid-methyl methacrylate and itaconic acid-acrylamide employing microwave irradiation as

*Address correspondence to: Mohamed H. El-Newehy and Ayman El-Faham, Department of Chemistry, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia. E-mail: melnewehy@hotmail.com and aelfaham@ksu.edu.sa

Color versions of one or more figures in this article can be found online at www.tandfonline.com/lmsa.

# How to write the Introduction?

- ❑ Should state briefly and clearly your purpose.
- ❑ Justify why did you choose that subject and why is it important.
- ❑ Start writing the paper when the work is still in progress.
- ❑ From problem to solution.
- ❑ Present tense for the established knowledge.
- ❑ Mention your previously published papers.
- ❑ Define specialized terms and abbreviations.

## ❑ Suggested rules:

- **Present first the nature and scope of the work.**
- **Literature review (important background and state of the art.**
- **State the methods of investigation (reasons for the choice).**
- **State the principal conclusions.**

# Methods
## (Experimental Part)

**The Methods section describes the process you undertook to complete the research.**

# How to write the Materials and Methods?

- **Purpose:** Describe and justify the experimental design so that the experiments could be repeated by others.
- Reproducibility = basis of science.
- Must give the full details.
- Past tense.
- Presentation with sub headings.
- If new method (unpublished): provide all the needed details.
- Rule: enough information must be given so that the experiments could be reproduced by a competent colleague.
- Avoid mistake: No mixing some of the results.

**The method is written as a process description, not as a lab manual procedure.**

- ❑ explains materials used
- ❑ explains analytical techniques used
- ❑ details experimental procedures
- ❑ describes techniques for tracking functional variables (timing, temperature, humidity, etc.)

# Methods

## 2 Experimental

### 2.1 Materials

Itaconic acid (IAA), acrylamide (AA) and methyl methacrylate (MMA) were supplied from Sigma-Aldrich. *N,N*\-Azobisisobutyronitrile (AIBN) was supplied from Hanover and was re-crystallized from absolute ethanol before use. Lead (II) nitrate and copper (II) sulfate were supplied from Fluka. All solvents were dried before use.

### 2.2 Measurements

The microwave irradiation employing a multimode reactor (Synthos 3000, Anton Paar GmbH, and 1400 W maximum magnetron) was used to prepare the copolymers. Fourier transform infrared spectroscopy (FT-IR) spectra were recorded on a Nicolet 560 Magna Spectrometer. Thermal properties of the copolymers and their complexes were examined using thermogravimetric analysis (TGA) under nitrogen, in the temperature range 30–800°C with a heating rate of 10°C/min. and differen-ial scanning calorimetery (DSC) which was carried out TA-Q500 in which Specimens of (5–10 mg) were

Synthesis of copolymers.

### 2.3 General Procedure for Conventional Method

In a three-necked round-bottomed flask fitted with a condenser, methyl methacrylate (MMA) (5.00 g, 50.0 mmol) was mixed with itaconic acid (IAA) (1.12 g, 10.0 mmol) in 2-butanone (20 mL). The reaction mixture was thoroughly purged with nitrogen for 10 min. Copolymerization was initiated by adding azobisisobutyronitrile (AIBN, 0.1 g, 1.65 % w/w) and then was heated at 60°C, under nitrogen atmosphere for 24 h. The reaction was cooled down to room temperature, and then the copolymer was precipitated by adding diethyl ether. The precipitated copolymer poly(methyl methacrylate-*co*-itaconic aicd)–PMIAA was filtered, washed with diethyl ether (20 mL) and then dried in oven under vacuum at 40°C for 24 h.

### 2.4 General Procedure for Microwave-Assisted Synthesis

Microwave-assisted copolymerization of IAA with MMA or AA was carried out using the procedure described earlier by Osman *et al* (30) which can be summarized as th following; Employing a multimode reactor (Sy

# Results

**The Results section**

- **DESCRIBES but DOES NOT INTERPRET the your research results.**
- **Presents the data using graphs and tables to reveal any trends that you found and Describes these trends to the reader.**
- **The presentation of data may be in the order to correspond with the Methods.**
- **Negative results are results and worth including in your report.**

# Results

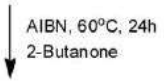
## 3 Results and Discussion

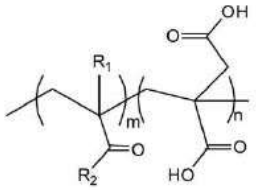
### 3.1 Synthesis of Copolymers

The two copolymers itaconic acid-methyl methacrylate and itaconic acid-acrylamide (PMIAA and PAIAA) with

the ...
(CONH) for the ...
3349 $cm^{-1}$ for the NH (Fig. ...
that, the intensity of the –OH and –C– group was increased as the ratio of IAA ... copolymer.

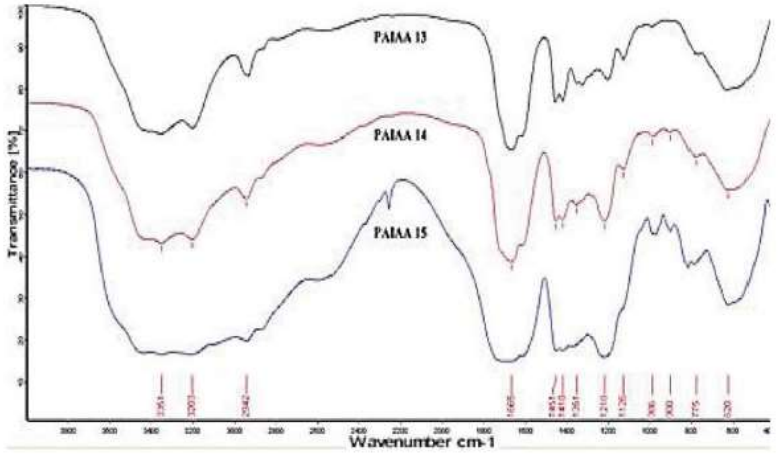

$R_1 = CH_3$, $R_2 = OCH_3$ Methylmethacrylate (MMA) Itaconic acid (IAA)
$R_1 = H$, $R_2 = NH_2$ Acrylamide (AA)




$R_1 = CH_3$, $R_2 = OCH_3$ Poly(methyl methacrylate-*co*-itaconic aicd) -PMIAA
$R_1 = H$, $R_2 = NH_2$ Poly(acrylamide-*co*-itaconic aicd) -PAIAA

**Sch. 1.** Copolymerization of itaconic acid with acrylic monomers.




(b)

**Fig. 1.** FT-IR Spectrum of (a) PMIAAs; and (b) PAIAAs copolymers.

The copolymers prepared by both conventional method and microwave irradiation showed the same spectral data. In addition, the elemental microanalysis confirmed the structures of the copolymers, which in a good agreement with the calculated values as shown in (Table 2).

### 3.3 Thermogravimetric Analysis (TGA)

The thermal properties of the prepared copolymers were evaluated by thermogravimetric analysis (TGA) as shown in (Figs. 2a–c) and data was summarized in (Table 3), in which the weight of a sample is measured

# How to write the Results?

- Result section = Core of the paper.
- Presentation of the data but predigested: only representative data not all.
- No more method description.
- Not yet data interpretation: the discussion section is designed to tell what they mean.
- No references.
- No need to cite Figures and Tables.
- All Figures are labeled and referenced in the text prior to the Figure.
- Past tense.
- For example; If n variable tested;
  - Present in Table or Graphs only those which affect the reaction.

# Discussion

What's the Discussion? Interpretation.

- ❑ This section offers your interpretations and conclusions about your findings.
- ❑ How do your results relate to the goals of the study and to previous studies.
- ❑ This is your chance to demonstrate your ability to synthesize, analyze, evaluate, interpret, and reason effectively.
- ❑ Your readers are looking for well-supported opinions,
- ❑ You will need to think carefully about your findings in order to draw conclusions that are neither too narrow nor too broad.
- ❑ Verb tense
  - Present for established knowledge
  - Past for the new (own) results.

# Conclusions

**Synthesize, don't summarize:**

- **Brief** summary of the paper's main points.
- **Do not** simply repeat things that were in your paper.
- **Show** your reader how the points you made and the support and examples you used fit together.
- **Pull it all together.**

## 4 Conclusions

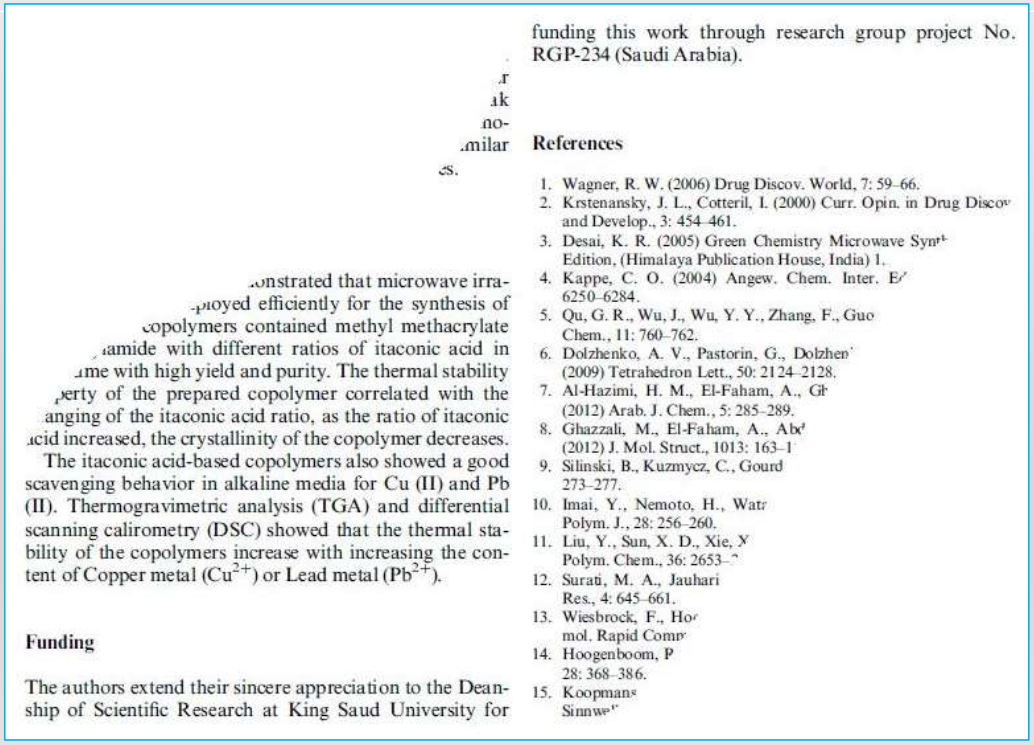
In conclusion, we have demonstrated that microwave irradiation could be employed efficiently for the synthesis of two types of copolymers contained methyl methacrylate and acrylamide with different ratios of itaconic acid in short time with high yield and purity. The thermal stability property of the prepared copolymer correlated with the changing of the itaconic acid ratio, as the ratio of itaconic acid increased, the crystallinity of the copolymer decreases.

The itaconic acid-based copolymers also showed a good scavenging behavior in alkaline media for Cu (II) and Pb (II). Thermogravimetric analysis (TGA) and differential scanning calirometry (DSC) showed that the thermal stability of the copolymers increase with increasing the content of Copper metal ($Cu^{2+}$) or Lead metal ($Pb^{2+}$).

**Funding**

# How to write the Acknowledgments?

- Acknowledge.
  - Advisors (they are not responsible for the work).
  - Financial assistance (grants, fellowships, contractors, ….).



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**Funding**

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**References**

1. Wagner, R. W. (2006) Drug Discov. World, 7: 59–66.
2. Krstenansky, J. L., Cotteril, I. (2000) Curr. Opin. in Drug Discov and Develop., 3: 454–461.
3. Desai, K. R. (2005) Green Chemistry Microwave Synth Edition, (Himalaya Publication House, India) 1.
4. Kappe, C. O. (2004) Angew. Chem. Inter. Ed 6250–6284.
5. Qu, G. R., Wu, J., Wu, Y. Y., Zhang, F., Guo Chem., 11: 760–762.
6. Dolzhenko, A. V., Pastorin, G., Dolzhen (2009) Tetrahedron Lett., 50: 2124–2128.
7. Al-Hazimi, H. M., El-Faham, A., Gh (2012) Arab. J. Chem., 5: 285–289.
8. Ghazzali, M., El-Faham, A., Abd (2012) J. Mol. Struct., 1013: 163–1
9. Silinski, B., Kuzmycz, C., Gourd 273–277.
10. Imai, Y., Nemoto, H., Wata Polym. J., 28: 256–260.
11. Liu, Y., Sun, X. D., Xie, Y Polym. Chem., 36: 2653–
12. Surati, M. A., Jauhari Res., 4: 645–661.
13. Wiesbrock, F., Ho mol. Rapid Comm
14. Hoogenboom, P 28: 368–386.
15. Koopmans Sinnwe

# References

- If you reference an outside source in your report, you should cite where you found that source.
- Cite only material that you have actually read.
- Avoid secondary materials (only significant, published references).
- Read carefully “the instruction to authors” of the journal.
- Place it all at the point of the sentence

# References


References

1. Wagner, R. W. (2006) Drug Discov. World, 7: 59–66.
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ng, F., Guo, H. M. (2009) Green

Dolzhenko, A. V., Chui, W. K. -2128.

., Ghazzali, M., Al-Farhan Kh.

d-Megeed, A., Al-Farhan, Kh. 67.

ne, A. (1987) Eur. Polym. J., 23:

e, S., Kakimoto, M. A. (1996)

cola, D. A. (1998) J. Polym. Sci.

, K. R. (2012) Arch. Appl. Sci.

Schubert, U. S. (2004) Macro-

2007) Macromol. Rapid Comm.,

ep, P., Klink, M., Schmitz, S., ahedron, 62: 4709–4714.



**Keywords:** Microwave synthesis, [illegible]


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Thank You