Winter 1-1-2020

Synthesis and Characterization of Chitosan based Catalyst for Catalysis Applications

Mostafa Radwan
mradwan@bue.edu.eg

ISSN 2278-3091
Volume 9, No.1, January – February 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse71912020.pdf
https://doi.org/10.30534/ijatcse/2020/71912020

Synthesis and Characterization of Chitosan based Catalyst for Catalysis Applications

Hany A. Elazab [1,2 *] , Yousab G. Remiz [1], Mostafa A. Radwan[1], M. A. Sadek[1]
1Department of Chemical Engineering, Faculty of Engineering, The British University in Egypt, El-Shorouk City, Cairo, Egypt.
2 Nanotechnology Research Centre (NTRC), the British University in Egypt (BUE), El-Sherouk City, Suez Desert Road, Cairo, 11837, Egypt
* Corresponding Author: Elazabha@vcu.edu

ABSTRACT

In this research, chitosan based catalyst synthesis and characterization was investigated for different application in catalysis as chitosan based catalyst was combined with metal oxides in order to be used in dye removal of methyl orange (MO). Diluted acetic acid was used to dissolve chitosan then different percentages for metallic ions were mixed with diluted chitosan and then, 500 µL were added to the sample to reduce the metal salts then, microwave was used to heat the mixture for 5 minutes and then dried at 80-100 °C. Finally, X- ray diffraction was used to confirm the catalyst prepared. The aim of this research is to investigate and explore the feasibility of chitosan/metallic ions composite for removing MO from aqueous solutions. The influence of several operating parameters for adsorption of MO, such as contact time, temperature and pH.

Key words: Dye removal, Chitosan, Metal oxides, catalyst, Wastewater treatment.

1. INTRODUCTION

This research main aim is to investigate the preparation and characterization of chitosan based catalyst for different catalytic applications. [1-7] It is also oriented to explain the performance of chitosan catalyst in several catalytic applications like dye removal in order to remove dyes from textile and wastewater treatment. [8-14]
Metal oxides are used in both types of heterogeneous and homogenous catalysis. Heterogeneous catalyst is better than homogeneous catalyst as it could be separated from reaction mixture more easily. [15-22] Chitosan is a natural polysaccharide with appealing intrinsic properties, such as, non-toxicity, biocompatibility and biodegradability. [23-31] Moreover, chitosan displays a powerful adsorption performance toward dyes from aqueous solutions. [32-40] It is massively applied in the removal of organic dyes and metal ions However, pure chitosan as an adsorbent has several disadvantages, including high cost and low chemical stability, which limits its application in adsorption processes. [41-45]
The research focused recently on investigating new methods of eliminating polluted dyes from industrial wastewaters was highly interested. Azo dyes appear to be the most effective among different types of the dyes used, because these dyes are widely used in many textile, food and color paper industries. Azo dyes usually have a complex aromatic structure and nearly complex structural azo(-N= N-) groups. [46-50] These colors are deeply colored because the azo-groups in these colours, and therefore the color can go away if these groups are broken. [51-54]Because these compounds have a rigid structure, it is not easy to break these materials into smaller fragments in normal condition.
This type of dyes can cause many types of environmental pollution including air, water and soil pollution by the presence of these dyes in wastewater. [55-58] Some of these teeth can also produce carcinogenic materials and/or release certain toxic substances into the environment. In general, certain physical, biological and chemical methods involve traditional methods of removing dyes from textile industrial wastewaters. Recently, methods for photodegradation seem to be an interesting alternative approach which can efficiently be used to remove these dyes from textile effluents. [59-62]
Because of its clear and distinct colour change, methyl orange is a pH indicator commonly used in titrations. Since the color changes at the pH of a mid-force acid, it is typically used in acid titrations. In contrast to a universal indicator, methyl orange does not change color in its entirety, but it has a stronger final point. In a less acidic solution, methyl orange moves from red to orange and finally to yellow with the reverse resulting in an increased acidity solution. In acidic conditions the entire color change occurs. It is reddish in acid and yellow in alkaline. [63-64]
Methyl orange moves from red to orange in a solution which is less acidic and finally becomes yellow in order to increase its acidity. In acidic conditions the entire color change takes place. It's reddish in an acid and yellow in alkaline. [64-66]

2. EXPERIMENTAL

Solubility of chitosan was investigated using three different solution which are (water, acidic acid and diluted acidic acid) to find out that the optimum solution that have the ability to dilute the chitosan is diluted acidic acid mixture within 1-2% in distilled water and with the presence of stirring and heating using hot stirrer.

Different percentage of chitosan were prepared with metal ions such as (Cu, Ni, Fe,Co). Then 500 µL of Hydrazine hydrate were added as a strong reducing agent to the mixture of chitosan and metal ions then heated using microwave for 5 minutes. Then, sample was dried using oven and catalysts was collected for being used in the process. Then, 50 ppm concentration of methyl orange day is prepared in a diluted distilled water. The wavelength of 50 ppm of methyl orange was checked to be 465 nm. After preparing day samples a standard curve have to be drawn to study the relation between absorbance with the concentration of dye by the catalysts prepared. To assure accurate standard curve different concentrations were used such as [35, 30, 25, 20, 15, and 10] as a trial with constant volumes. After getting the mass and volume required using the following equation mv = mv standard curve is done. Using the extracted catalysts as every portion is divided by five to be used for all dye samples. Catalysts absorbance is calculated over different time intervals as follow [10, 20, 30, 40, and 50] minutes using 50 ppm concentration of dye. Prepared samples after that are poured into cylindrical flasks to be diluted with distilled water to rich total volume of 50 ml. Finally, portions for each sample are inserted into the spectrophotometer to know the rate of absorbance of the catalyst over dye concentration for each sample.

3. RESULTS AND DISCUSSION

Figure 1 shows the effect of reduction after adding 500 µL Hydrazine hydrate on solution of chitosan and copper and on the sample 0.2 chitosan the sample has changed the color because it has a little amount of chitosan so the reduction come fast before entering the microwave.

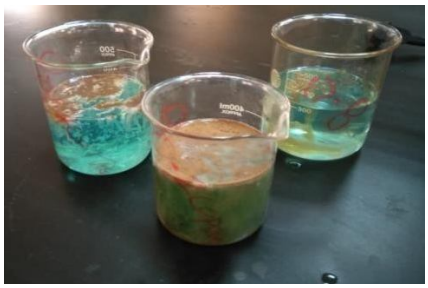

Figure 1: Effect of adding Hydrazine hydrate on copper and chitosan solution

Figure 2: Effect of adding Hydrazine hydrate on Nickel and chitosan solution

Figure 2 shows the effect of reduction after adding 500 µL Hydrazine hydrate on solution of chitosan and nickel and we also see here that the color changed fast on the sample 0.6 ,0.4 and 0.2 g from chitosan and this indicator that the reduction is done.

Figure 3: Effect of adding Hydrazine hydrate on Iron and chitosan solution

Figure 3 shows the effect of reduction after adding 500 µL Hydrazine hydrate on solution of chitosan and ferric on the sample 0.4 and 0.6 gram from chitosan and the color changed.

Table 1: Concentration Calculations for Iron based catalyst supported on different wt % Chitosan

Chitosan	Ferric	Resulted
0.9	0.2945	**1.2**
0.8	0.589	**0.82**
0.6	1.178	**1.67**
0.4	1.767	**2.2**
0.2	**2.356**	**2.02**

Figure 4: Chitosan Based Iron Oxide Catalyst

Table 2: Concentration Calculations for Copper based catalyst supported on different wt % Chitosan

Chitosan	Copper	Resulted
0.9	0.2167	**0.8**
0.8	0.433	**0.8**
0.6	0.8667	**1.1**
0.4	1.3	**1.24**
0.2	**1.733**	**1.58**

Figure 5: Chitosan Based Copper Oxide Catalyst

Table 3: Concentration Calculations for Nickel based catalyst supported on different wt % Chitosan

Chitosan	Nickel	Resulted
0.9	0.2621	**0.91**
0.8	0.525	**1.08**
0.6	1.05	**2.1**
0.4	1.576	**1.8**
0.2	**2.101**	**1.7**

Figure 6: Chitosan Based Nickel Oxide Catalyst

Figure 7 display the XRD diffraction pattern of copper chloride nanoparticles which was prepared with the microwave method, and the characterization of (CuCl) was achieved by XRD pattern of catalyst sample as we see in figure 7. XRD of CuCl match that reference code is 01-081-1841 corresponding to cubic structure and the diffraction peaks are ascribed to the (111), (200), (220), (311), (222), and (400).

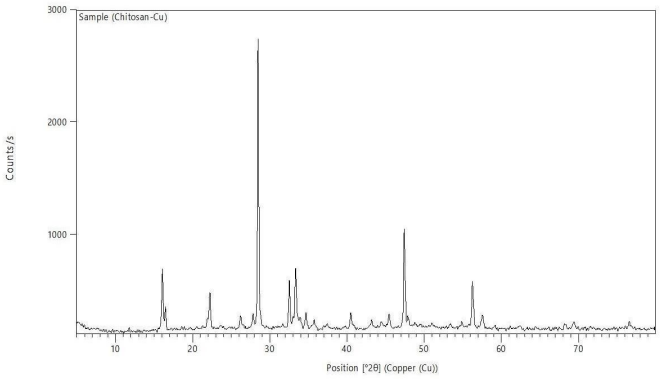

Figure 7: XRD pattern of Copper based catalyst

Figure 8 display the XRD diffraction pattern of iron chloride nanoparticles which we prepared with the microwave method. And the characterization of $[FeCl_2(H_2O)_4]$ was achieved by XRD pattern of catalyst sample as we see in figure 8. XRD of $[FeCl_2(H_2O)_4]$ match that reference code is 01-071-0917corresponding to Monoclinic structure and the diffraction peaks are ascribed to the (100), (001), (110), (012), (111), (120), (222), (231) and (024).

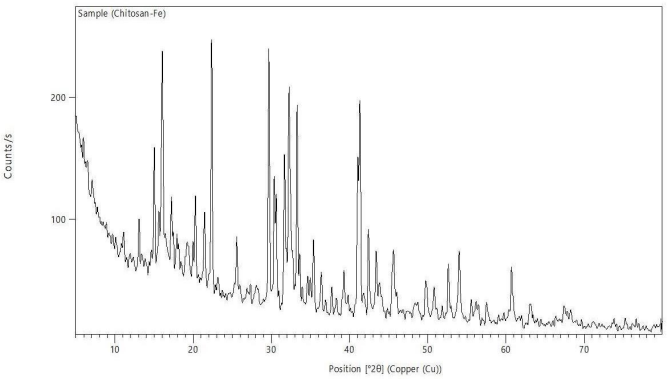

Figure 8: XRD pattern of Iron based catalyst

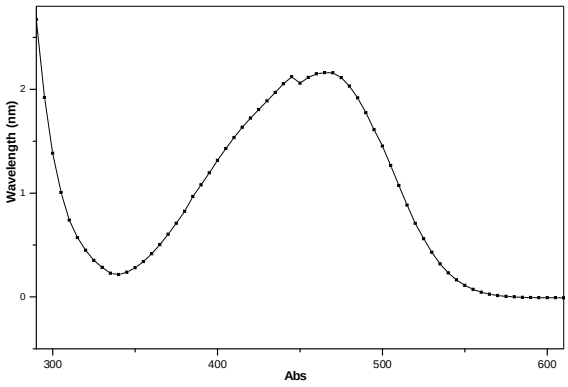

Figure 9: Wave Length Curve of Methyl Orange

In order to find the wave length of the methyl orange this curve was obtained by using the Spectrophotometer by applying the dye (methyl-orange) in the device and start to gain the reading of the wave length curve it showed that peak of the curve was 465 nm which fits with the known wave length of methyl orange in the books done by scientist.The methyl orange has been prepared with concentration 50 PPM by applying the equation MV=MV to obtain the needed concentration

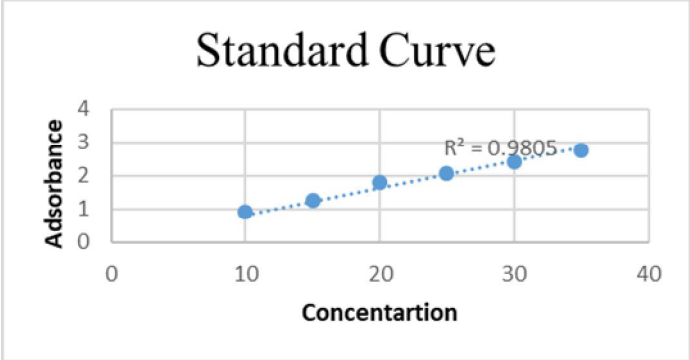

Figure 10 : Standard curve for Methyl orange

From the curve, it is evident that λ_{max} was determined at a value of = 465 nm, which is in accordance with values in literature. For practical purpose, the wavelength will be fixed at 465 nm whilst carrying out all absorbance measurements of both the standard curve and the subsequent sample determinations.

The standard curve shows the relation between concentrations and absorbance. The curve was obtained by applying different concentrations of methyl orange and obtains its absorbance. This curve makes the reading of concentrations more easily when applying the samples as the absorbance hit the curve and read the concentration. The curve gave R^2 =0.9805 which is acceptable.

4. CONCLUSION

This research main aim is to study chitosan based catalyst and its application and characterizations. Chitosan based catalyst has many applications including dye removal. Spectrophotometer is the device that was used in our experiment to measure the dye removal and make sure that the paper reached its goal by applying the application of dye removal. The results showed that chitosan based catalyst with metal ions has a great effect in dye removal and the best metal ions gave good results is nickel. In order to study the characterizations of the chitosan based catalyst wide x-ray diffraction (WXRD) test was applied and it showed a great result.

ACKNOWLEDGEMENT

We express our deep gratitude to British University in Egypt (BUE). This work was partially performed using the facilities at the Nanotechnology Research Centre (NTRC) at the British University in Egypt (BUE).

REFERENCES

1. Chen S.T., **Synthesis of Pd/Fe3O4 Hybrid Nanocatalysts with Controllable Interface and Enhanced Catalytic Activities for CO Oxidation,** *Journal of Physical Chemistry C*, Vol. 116, pp. 2969-12976, March 2012. https://doi.org/10.1021/jp3036204
2. Radwan N.R.E., El-Shall M.S., Hassan H.M.A., **Synthesis and characterization of nanoparticle Co3O4, CuO and NiO catalysts prepared by physical and chemical methods to minimize air pollution**, *Applied Catalysis A: General*, Vol. 331, pp. 8-18, August 2007.
3. Wang H.L., **Ni(OH)(2) Nanoplates Grown on Graphene as Advanced Electrochemical Pseudocapacitor Materials**, *Journal of the American Chemical Society*, Vol. 132, 21, pp. 7472-7477, February 2010. https://doi.org/10.1021/ja102267j
4. Wang W.W., Zhu Y.J., Ruan M.L., **Microwave-assisted synthesis and magnetic property of magnetite and hematite nanoparticles**, *Journal of Nanoparticle Research*, Vol. 9, 3, pp. 419-426, April 2007.
5. Elazab H., **Microwave-assisted synthesis of Pd nanoparticles supported on FeO, CoO, and Ni(OH) nanoplates and catalysis application for CO oxidation**, *Journal of Nanoparticle Research*, Vol. 16, 7, pp. 1-11, November 2014. https://doi.org/10.1007/s11051-014-2477-0
6. Mankarious R.A., et al., **Bulletproof vests/shields prepared from composite material based on strong polyamide fibers and epoxy resin**, *Journal of Engineering and Applied Sciences*, Vol. 12, 10, pp. 2697-2701, May 2017.
7. Mohsen W., Sadek M.A., Elazab H.A., **Green synthesis of copper oxide nanoparticles in aqueous medium as a potential efficient catalyst for catalysis applications**, *International Journal of Applied Engineering Research*, Vol. 12, 24, pp. 14927-14930, July 2017.
8. Mostafa A.R., Omar H.A.-S., Hany A.E., **Preparation of Hydrogel Based on Acryl Amide and Investigation of Different Factors Affecting Rate and Amount of Absorbed Water**, *Agricultural Sciences*, Vol. 8, pp. 2-11, June 2017.
9. Radwan M.A., et al., **Mechanical characteristics for different composite materials based on commercial epoxy resins and different fillers**, *Journal of Engineering and Applied Sciences*, Vol. 12, 5, pp. 1179-1185, May 2017.

10. Andrade A.L., **Catalytic Effect of Magnetic Nanoparticles Over the H(2)O(2) Decomposition Reaction**, *Journal of Nanoscience and Nanotechnology*, Vol. 9, 6, pp. 3695-3699, June 2009. https://doi.org/10.1166/jnn.2009.NS53
11. Kustov A.L., **CO methanation over supported bimetallic Ni-Fe catalysts: From computational studies towards catalyst optimization**, *Applied Catalysis a-General*, Vol. 320, pp. 98-104, November 2007.
12. Lohitharn N., Goodwin J.G., **Impact of Cr, Mn and Zr addition on Fe Fischer-Tropsch synthesis catalysis: Investigation at the active site level using SSITKA**, *Journal of Catalysis*, Vol. 257, 1, pp. 142-151, August 2008. https://doi.org/10.1016/j.jcat.2008.04.015
13. Moreau F., Bond G.C., **CO oxidation activity of gold catalysts supported on various oxides and their improvement by inclusion of an iron component**, *Catalysis Today*, Vol. 114, 4, pp. 362-368, October 2006. https://doi.org/10.1016/j.cattod.2006.02.074
14. Sarkari M., **Fischer-Tropsch synthesis: Development of kinetic expression for a sol-gel Fe-Ni/Al2O3 catalyst**, F*uel Processing Technology*, Vol. 97, pp. 130-139, April 2012. https://doi.org/10.1016/j.fuproc.2012.01.008
15. Elazab H., **The Effect of Graphene on Catalytic Performance of Palladium Nanoparticles Decorated with FeO, CoO, and Ni (OH): Potential Efficient Catalysts Used for Suzuki Cross-Coupling**, *Catalysis Letters*, Vol. 147, 6, pp. 1510-1522, July 2017.
16. Elazab H.A., **The continuous synthesis of Pd supported on Fe3O4 nanoparticles: A highly effective and magnetic catalyst for CO oxidation**, *Green Processing and Synthesis*, Vol. 6, 4, pp. 413-424, May 2017. https://doi.org/10.1515/gps-2016-0168
17. Elazab H.A., Sadek M.A., El-Idreesy T.T., **Microwave-assisted synthesis of palladium nanoparticles supported on copper oxide in aqueous medium as an efficient catalyst for Suzuki cross-coupling reaction**, *Adsorption Science & Technology*, Vol. 36, pp. 1352-1365, May 2018.
18. Elazab H.A., **Highly efficient and magnetically recyclable graphene-supported Pd/Fe3O4 nanoparticle catalysts for Suzuki and Heck cross-coupling reactions**, *Applied Catalysis A: General*, Vol. 491, pp. 58-69, February 2015.
19. Hirvi J.T., et al., **CO oxidation on PdO surfaces**, *Journal of Chemical Physics*, Vol. 133, pp. 8-14, August 2010. https://doi.org/10.1063/1.3464481
20. Iglesias-Juez A., N**anoparticulate Pd Supported Catalysts: Size-Dependent Formation of Pd(I)/Pd(0) and Their Role in CO Elimination**, *Journal of the American Chemical Society*, Vol. 133, 12, pp. 4484-4489, March 2011.
21. Ivanova A.S., **Metal-support interactions in Pt/Al2O3 and Pd/Al2O3 catalysts for CO oxidation**, *Applied Catalysis B-Environmental*, Vol. 97, 1-2, pp. 57-71, April 2010.
22. Kim H.Y., Henkelman G., **CO Oxidation at the Interface between Doped CeO2 and Supported Au Nanoclusters**, *Journal of Physical Chemistry Letters*, Vol. 3, 16, pp. 2194-2199, January 2012. https://doi.org/10.1021/jz300631f
23. Chattopadhyay K., Dey R., Ranu B.C., **Shape-dependent catalytic activity of copper oxide-supported Pd(0) nanoparticles for Suzuki and cyanation reactions**, T*etrahedron Letters: International Organ for the Rapid Publication of Preliminary Communications in Organic Chemistry*, Vol. 50, 26. pp. 3164-3167, December 2009.
24. Hoseini S.J., **Modification of palladium-copper thin film by reduced graphene oxide or platinum as catalyst for Suzuki-Miyaura reactions**, *Applied Organometallic Chemistry*, Vol. 31, pp. 5-12, March 2017.
25. Hosseini-Sarvari M., Razmi Z., **Palladium Supported on Zinc Oxide Nanoparticles as Efficient Heterogeneous Catalyst for Suzuki Miyaura and Hiyama Reactions under Normal Laboratory Conditions**, *Helvetica Chimica Acta*, Vol. 98, 6, pp. 805-818, April 2015.
26. Nasrollahzadeh M., Ehsani A., Jaleh B., **Preparation of carbon supported CuPd nanoparticles as novel heterogeneous catalysts for the reduction of nitroarenes and the phosphine-free Suzuki Miyaura coupling reaction**, *New Journal of Chemistry*, Vol. 39, 2, pp. 1148-1153, February 2015. https://doi.org/10.1039/C4NJ01788A
27. Nasrollahzadeh M., **Palladium nanoparticles supported on copper oxide as an efficient and recyclable catalyst for carbon(sp2) carbon(sp2) cross-coupling reaction**, *Materials Research Bulletin*, Vol. 68, pp. 150-154, April 2013.
28. Mandali P.K., Chand D.K., **Palladium nanoparticles catalyzed Suzuki cross-coupling reactions in ambient conditions**, *Catalysis Communications*, Vol. 31, pp.16-20, November 2016.
29. Wang Y., **CuO Nanorods-Decorated Reduced Graphene Oxide Nanocatalysts for Catalytic Oxidation of CO**, *Catalysts*, Vol. 6, 12, pp. 214-220, September 2016. https://doi.org/10.3390/catal6120214
30. Igarashi H., Uchida H., Watanabe M., **Mordenite-supported noble metal catalysts for selective oxidation of carbon monoxide in a reformed gas**, *Chemistry Letters*, Vol. 11, pp. 1262-1263, October 2000.
31. Liu W.H., Fleming S., Lairson B.M., **Reduced intergranular magnetic coupling in Pd/Co multilayers**, *Journal of Applied Physics*, Vol. 79, 7, pp. 3651-3655, May 1996.

32. Luo J.Y., **Mesoporous Co(3)O(4)-CeO(2) and Pd/Co(3)O(4)-CeO(2) catalysts: Synthesis, characterization and mechanistic study of their catalytic properties for low-temperature CO oxidation**, *Journal of Catalysis*, Vol. 254, 2, pp. 310-324, June 2008. https://doi.org/10.1006/jcat.1996.0213
33. Pavlova S.N., **The influence of support on the low-temperature activity of Pd in the reaction of CO oxidation on Kinetics and mechanism of the reaction**, *Journal of Catalysis*, Vol. 161, 2, pp. 517-523, May 1996.
34. Diyarbakir S.M., Can H., Metin Ã.n., **Reduced Graphene Oxide-Supported CuPd Alloy Nanoparticles as Efficient Catalysts for the Sonogashira Cross-Coupling Reactions**, A*cs Applied Materials & Interfaces*, Vol. 7, 5, pp. 3199-3206, March 2015.
35. Feng Y.-S., et al., **ChemInform Abstract: PdCu Nanoparticles Supported on Graphene: An Efficient and Recyclable Catalyst for Reduction of Nitroarenes**, *ChemInform*, Vol. 46, pp. 4-12, August 2015.
36. Feng Y.-S., et al., **PdCu nanoparticles supported on graphene: an efficient and recyclable catalyst for reduction of nitroarenes**, *Tetrahedron*, Vol. 70, 36, pp. 6100-6105, May 2014.
37. Liu Y., et al., **Ultrasensitive electrochemical immunosensor for SCCA detection based on ternary Pt/PdCu nanocube anchored on three-dimensional graphene framework for signal amplification**, *Biosensors & Bioelectronics*, Vol. 79, pp. 71-78, July 2016.
38. Shafaei Douk A., Saravani H., Noroozifar M., **Novel fabrication of PdCu nanostructures decorated on graphene as excellent electrocatalyst toward ethanol oxidation**, I*nternational Journal of Hydrogen Energy*, Vol. 42, 22, pp. 15149-15159, August 2017.
39. Hany A. Elazab, **Investigation of Microwave-assisted Synthesis of Palladium Nanoparticles Supported on Fe_3O_4 as an Efficient Recyclable Magnetic Catalysts for Suzuki Cross – Coupling,** *The Canadian Journal of Chemical Engineering*, Vol. 96, 12, pp. 250-261, January 2019. https://doi.org/10.1002/cjce.23402
40. Hany A. Elazab, **Laser Vaporization and Controlled Condensation (LVCC) of Graphene supported Pd/Fe_3O_4 Nanoparticles as an Efficient Magnetic Catalysts for Suzuki Cross – Coupling**, *Biointerface Research in Applied Chemistry*, Vol. 8, 3, pp. 3314 – 3318, August 2018.
41. Hany A. Elazab, **The catalytic Activity of Copper Oxide Nanoparticles towards Carbon Monoxide Oxidation Catalysis: Microwave – Assisted Synthesis Approach**, *Biointerface Research in Applied Chemistry*, Vol. 8, 3, pp. 3278 – 3281, June 2018.
42. M. A. Radwan, Omar Al-Sweasy, M. A. Sadek, Hany A. Elazab, **Investigating the Agricultural Applications of Acryl Amide based Hydrogel,** *International Journal of Engineering and Technology(UAE)*, Vol. 7, 4.29, pp. 168-171, April 2018.
43. Fatma Zakaria, M. A. Radwan, M. A. Sadek, Hany A. Elazab, **Insulating material based on shredded used tires and inexpensive polymers for different roofs**, *International Journal of Engineering and Technology(UAE)*, Vol. 7, 4, pp. 1983-1988, June 2018. https://doi.org/10.14419/ijet.v7i4.14081
44. Reem Nasser, M. A. Radwan, M. A. Sadek, Hany A. Elazab, **Preparation of insulating material based on rice straw and inexpensive polymers for different roofs**, *International Journal of Engineering and Technology(UAE)*, Vol. 7, 4, pp. 1989-1994, June 2018.
45. Mostafa Ghobashy, Mamdouh Gadallah, Tamer T. El-Idreesy, M. A. Sadek, Hany A. Elazab, **Kinetic Study of Hydrolysis of Ethyl Acetate using Caustic Soda**, *International Journal of Engineering and Technology(UAE)*, Vol. 7, 4, pp. 1995-1999, June 2018.
46. Nourhan Sherif Samir, Mostafa A. Radwan, M. A. Sadek, Hany A. Elazab, **Preparation and Characterization of Bullet-Proof Vests Based on Polyamide Fibers**, *International Journal of Engineering and Technology(UAE)*, Vol. 7, 3, pp. 1290-1294, May 2018.
47. Basant Ashraf, Mostafa A. Radwan, M. A. Sadek, Hany A. Elazab, **Preparation and Characterization of Decorative and Heat Insulating Floor Tiles for Buildings Roofs**, *International Journal of Engineering and Technology (UAE)*, Vol. 7, 3, pp. 1295-1298, May 2018. https://doi.org/10.14419/ijet.v7i3.13177
48. Mandali P.K., Chand D.K., **Palladium nanoparticles catalyzed Suzuki cross-coupling reactions in ambient conditions**, *Catalysis Communications*, Vol. 31, 5, pp. 16-20, October 2016.
49. Wang Y., **CuO Nanorods-Decorated Reduced Graphene Oxide Nanocatalysts for Catalytic Oxidation of CO**, *Catalysts*, Vol. 6, 12, pp. 214-223, April 2016.
50. Pavlova S.N., **The influence of support on the low-temperature activity of Pd in the reaction of CO oxidation on Kinetics and mechanism of the reaction**, *Journal of Catalysis*, Vol. 161, 2, pp. 517-523, July 1996.
51. Diyarbakir S.M., Can H., Metin Ã.n., **Reduced Graphene Oxide-Supported CuPd Alloy Nanoparticles as Efficient Catalysts for the Sonogashira Cross-Coupling Reactions**, A*cs Applied Materials & Interfaces*, Vol. 7, 5, pp. 3199-3206, June 2015.
52. M. A. Radwan, Mohamed Adel Rashad, M. A. Sadek, Hany A. Elazab, S**ynthesis, Characterization and Selected Application of Chitosan Coated Magnetic Iron Oxide Nanoparticles**, *Journal of Chemical Technology and Metallurgy*, Vol. 54, 2, pp. 303-310, June 2019.

53. Hosam H. Abdelhady, Hany A. Elazab, Emad M. Ewais, Mohamed Saber, Mohamed S. El-Deab, **Efficient Catalytic Production of Biodiesel Using Nano-Sized Sugarbeet Agro-Industrial waste**, *Fuel*, Vol. 261, pp. 116481, February 2020. https://doi.org/10.1016/j.fuel.2019.116481
54. Hany A. Elazab, M. A. Sadek, Tamer T. El-Idreesy, **Facile Synthesis of Reduced Graphene Oxide-Supported Pd/CuO Nanoparticles as an Efficient Catalyst for Cross-Coupling Reactions**, *Journal of Chemical Technology and Metallurgy*, Vol. 54, 5, pp. 934-946, August 2019.
55. Hany A. Elazab, Tamer T. El-Idreesy, **Polyvinylpyrrolidone - Reduced Graphene Oxide - Pd Nanoparticles as an Efficient Nanocomposite for Catalysis Applications in Cross-Coupling Reactions**, *Bulletin of Chemical Reaction Engineering and Catalysis*, Vol. 14, 3, pp. 490-501, December 2019.
56. Hany A. Elazab, Ali R. Siamaki, B. Frank Gupton, M. Samy El-Shall, **Pd-Fe_3O_4/RGO: a Highly Active and Magnetically Recyclable Catalyst for Suzuki Cross Coupling Reaction using a Microfluidic Flow Reactor**, *Bulletin of Chemical Reaction Engineering and Catalysis*, Vol. 14, 3, pp. 478-489, December 2019.
57. Hany A. Elazab, M. A. Radwan, Tamer T. El-Idreesy, **Facile microwave-assisted synthetic approach to palladium nanoparticles supported on copper oxide as an efficient catalyst for Heck cross-coupling reactions**, *International Journal of Nanoscience*, Vol. 18, 5, pp. 1850032, June 2019.
58. Hany A. Elazab, S. A. Hassan, M. A. Radwan, M. A. Sadek, **Microwave-assisted Synthesis of Graphene supported Hexagonal Magnetite for Applications in Catalysis**, *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, Vol. 8, 12, 5511-5513, 2019.
59. Hany A. Elazab, M. A. Radwan, M. A. Sadek, **Hydrothermal Synthesis of Palladium nanoparticles supported on Fe_3O_4 Nanoparticles: an Efficient Magnetic Catalysts for CO Oxidation**, *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, Vol. 8, 12, pp. 2792-2794, May 2019.
60. Tarek M. Aboul-Fotouh, Sherif K. Ibrahim, M. A. Sadek, Hany A. Elazab, **High Octane Number Gasoline-Ether Blend**, *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, Vol. 8, 9, pp. 732-739, March 2019.
61. Tarek M. Aboul-Fotouh, Islam Alaa, M. A. Sadek, Hany A. Elazab, **Physico-Chemical Characteristics of Ethanol–Diesel Blend Fuel**, *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, Vol. 8, 9, pp. 740-747, February 2019.
62. Hany A. Elazab, M. M. Seleet, Said M. A. Hassanein, M. A. Radwan, M. A. Sadek, **Synthesis and Characterization of Dinitro Pentamethylene Tetramine (DPT)**, *Journal of Advanced Research in Dynamical and Control System*, Vol. 11, 5S, pp. 310-318, August 2019.
63. Hany A. Elazab, M. M. Seleet, Said M. A. Hassanein, M. A. Radwan, M. A. Sadek, **Follow-up and Kinetic Model Selection of Dinitro Pentamethylene Tetramine (DPT)**, *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, Vol. 8, 8, pp. 2862-2866, October 2019.
64. Hany A. Elazab, Mamdouh Gadall, M. A. Sadek, Tamer T. El-Idreesy, **Hydrothermal Synthesis of Graphene supported Pd/Fe_3O_4 Nanoparticles as an Efficient Magnetic Catalysts for Suzuki Cross – Coupling**, *Biointerface Research in Applied Chemistry*, Vol. 9, 2, pp. 3906-3911, March 2019. https://doi.org/10.33263/BRIAC92.906911
65. Hany A. Elazab, M. M. Seleet, Said M. A. Hassanein, M. A. Radwan, M. A. Sadek, **3,7-Dinitro-1,3,5,7-Tetraazabicyclo[3,3,1]Nonane (DPT): An Important Intermediate in the Synthesis Route of one of the Most Powerful Energetic Materials (RDX/HMX)**, *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, Vol. 8, 452, pp. 88-95, April 2019.
66. Hany A. Elazab, Tamer T. El-Idreesy, **Optimization of the Catalytic Performance of Pd/Fe_3O_4 Nanoparticles Prepared via Microwave-assisted Synthesis for Pharmaceutical and Catalysis Applications**, *Biointerface Research in Applied Chemistry*, Vol. 9, 1, pp. 3794-3799, July 2019. https://doi.org/10.33263/BRIAC91.794799