Chemical Engineering Department

Graduation project II

Synthetic Wastewater Treatment Using Activated Carbon: Batch Adsorption

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Introduction

- Textile wastewater includes a large variety of dyes and chemical additions that make the environmental challenge for textile industry not only as liquid waste but also in its chemical composition.
- Main pollution in textile wastewater come from dyeing and finishing processes.

Figure 1: Effluent dyes Adapted from envirobites, riveted from: https://envirobites.org/2018/08/24/ornamental-plants-dont-dye/

Problem statment

Problem statment

- 10,000 different textile dyes with an estimated annual production of 700,000 metric tonnes are commercially available worldwide and 2-20% are directly discharged as aqueous effluents in different environmental components.

- Textile waste water has no pretreatment system, in the Palestinian scenario, which is undesirable for water environment.

- **The study discuss to treat synthesized wastewater with activated carbon (AC) under adsorption Methylene blue (MB) and Alizarin Red S (ARS).**

Objectives

1

To estimate AC possibilities of adsorption.

2

To study the effect of different parameters of adsorption on MB and ARS.

3

To investigate the adsorption performance of activated carbon of different dyes from synthetic wastewater.

4

To study kinetics and adsorption isotherm.

Materials

Adsorbents

❖ **Commercial activated carbon (AC) .**

✓ Purchased from Honeywell Fluke.

✓ Characterized by XRD, XRF.

❖ **Functionalized activated carbon with different nanomaterial**

✓ AC-TiO_2 prepared by sol -gel method.

✓ AC-Fe_3O_4 prepared by co-precipitation method .

✓ AC-AgNi prepared by impregnation method.

✓ Characterized by XRD.

Materials

Adsorbates

- ❖ **Commercial dyes .**
- ✓ Methylene blue (MB).
- ✓ Alizarin Red S (ARS).

MB	630 nm
ARS	517 nm

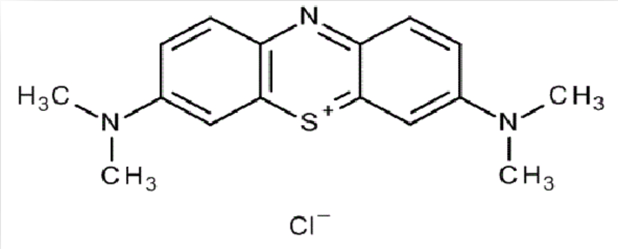

Figure 2: Methylene blue (MB) chemical structure

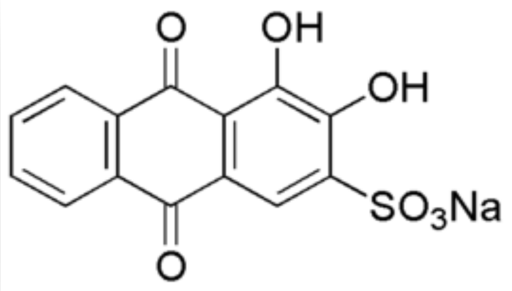

Figure 3: Alizarin Red S (ARS) chemical structure

Adsorbent Test

1. FT-IR characterization
2. XRD analysis
3. TGA analysis

FT-IR characterization

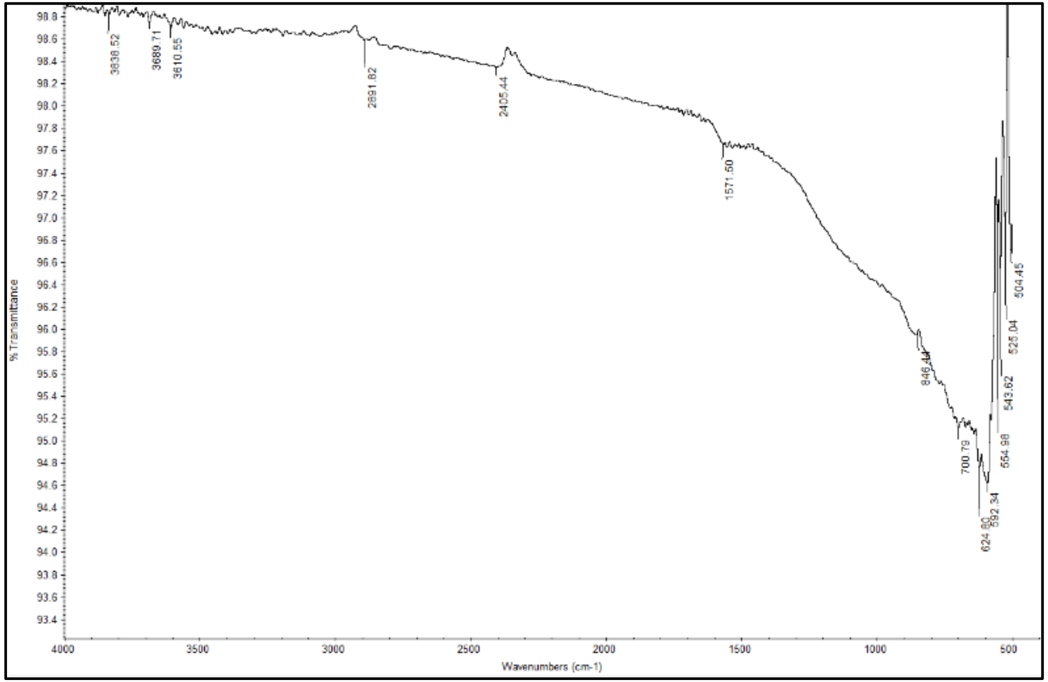

Figure 4: FT_IR spectra of AC sample.

AC wave number (cm^{-1})

1571	C=C
2405.44	C≡C
2891.82	C-H Saturated
3610.55	O-H Aliphatic

For investigate the surface group in raw material ,composite AC and composite Fe3O4-AC,TiO2 -AC.

FT-IR characterization

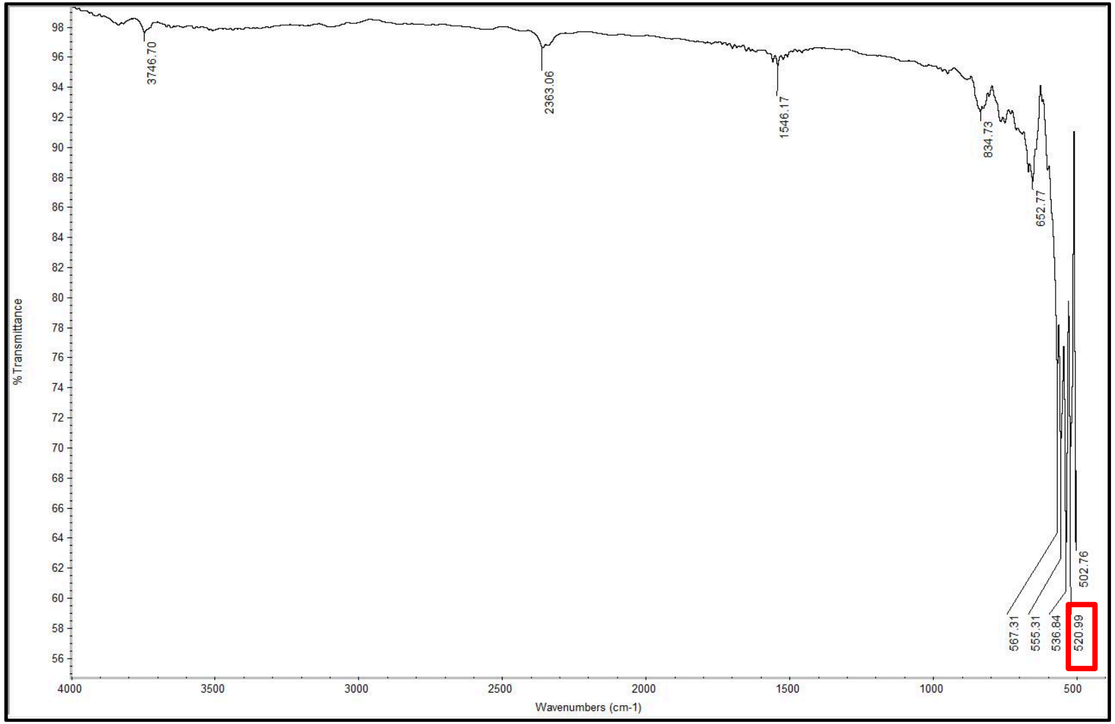

Figure 5: FT_IR spectra of AC-TiO_2 sample.

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AC-TiO_2 wave number (cm^{-1})

1546.2	C=C
2363.1	C≡C
3748.7	O-H Stretch
3425	TiO2-OH Stretching
1060	Ti-O
520	
1660	TiO2-OH Vibration

FT-IR characterization

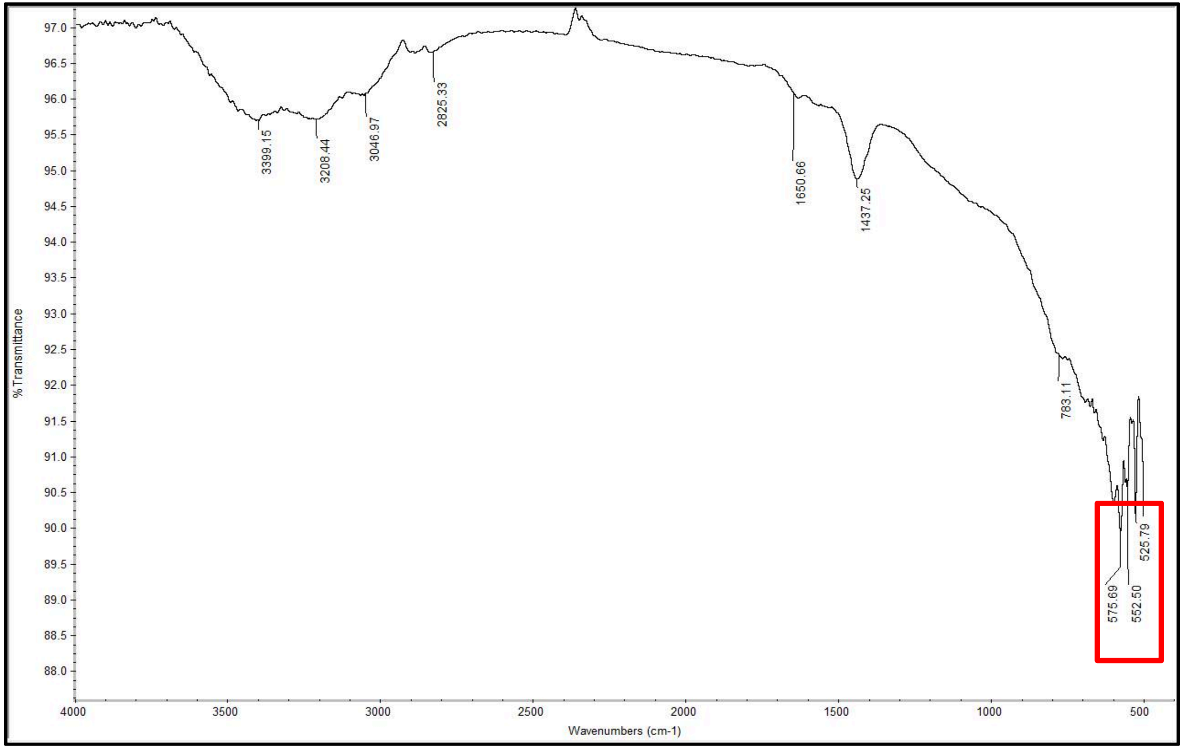


Figure 6: FT_IR spectra of AC-Fe_3O_4 sample.

AC-Fe_3O_4 wave number (cm^{-1})

1437.3	**C-O C-N C-C**
1650.6	C=C C=O C=N
2825.3	C-H (SP^3)
3047	C-H (SP)
3208.4	O-H N-H
3399.2	O-H N-H
520-630	Fe-O


FAILED

XRD analysis

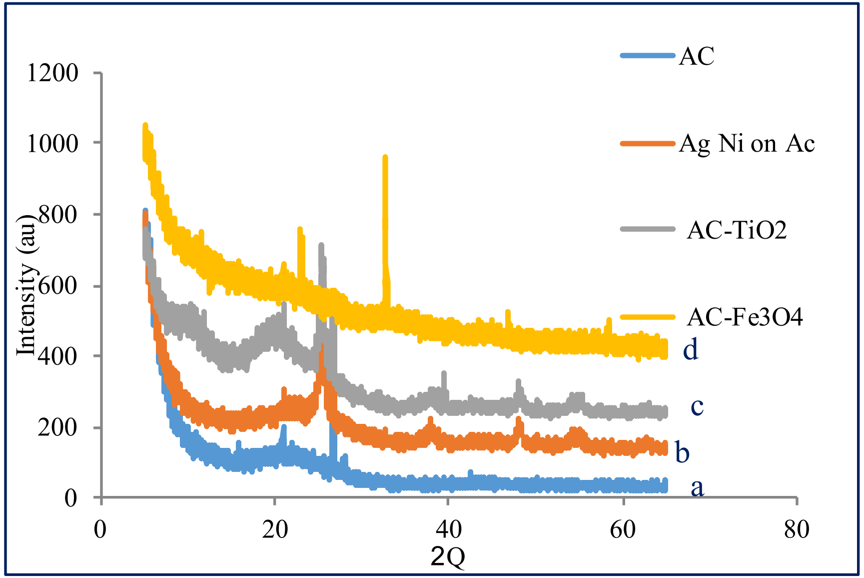


Figure 13: XRD patterns of samples (a)AC (b) AC-AgNi (c)AC-TiO_2 (d) AC-Fe_3O_4

Crystalline domain size of AC and functionalized AC

AC		AC-AgNi	
No. of peak	Crystalline domain size (nm)	**No. of peak**	Crystalline domain size (nm)
1	14.39462	[illegible]	[illegible]4
2	59.43523	**`2**	[illegible]04
AC-TiO_2		[illegible]	
No. of peak	Crystalline domain size (nm)	**No. of** [illegible]	[illegible]lline [illegible] (nm)
1	12.7424	**1**	[illegible]14
2	123.804	**2**	22.989
3	25.3723	**3**	13.7641

$$D = \frac{K \times \lambda}{\beta \times COS\,(2\Theta)}$$

Scherrer's formula

XRD is a technique that provides detailed information about the atomic structure of crystalline substances

TGA analysis (AC)

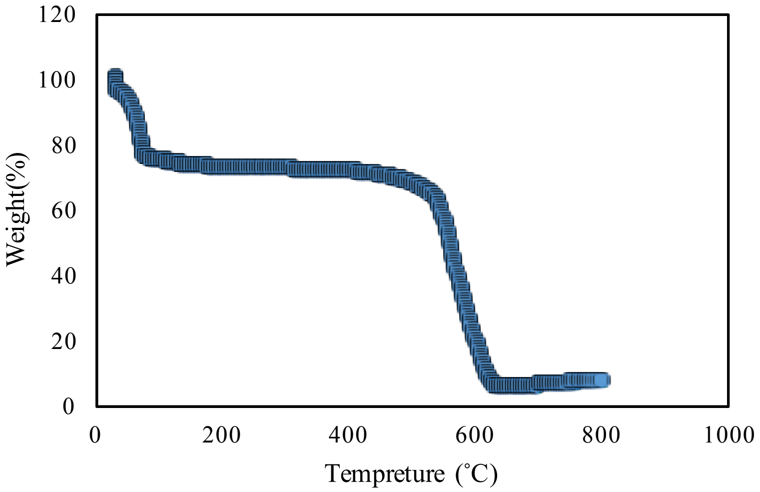


Figure 7: Thermogravimetric curves of AC with MB.

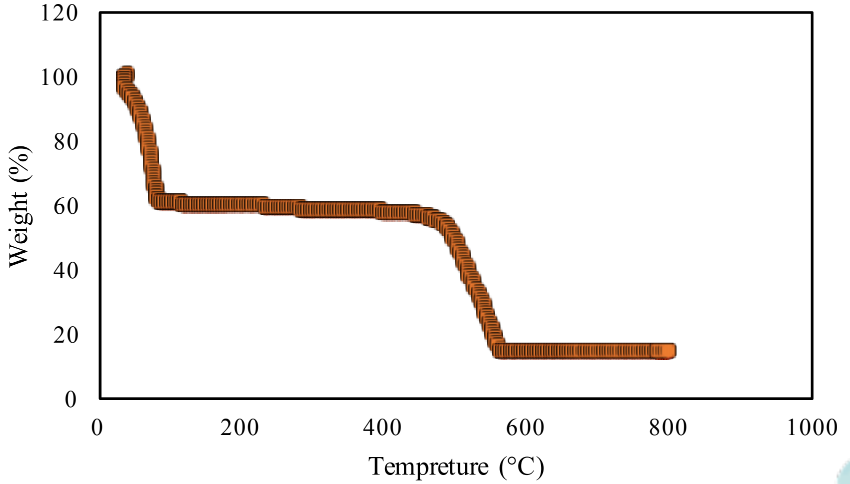


Figure 8: Thermogravimetric curves of AC with ASR.

Conditions

30-800 ℃

30-35 g

Thermogravimetric curves reflect the thermal stability of AC, AC-TiO_2 , AC-Fe_3O_4 with ARS and MB

TGA analysis (AC-TiO_2)

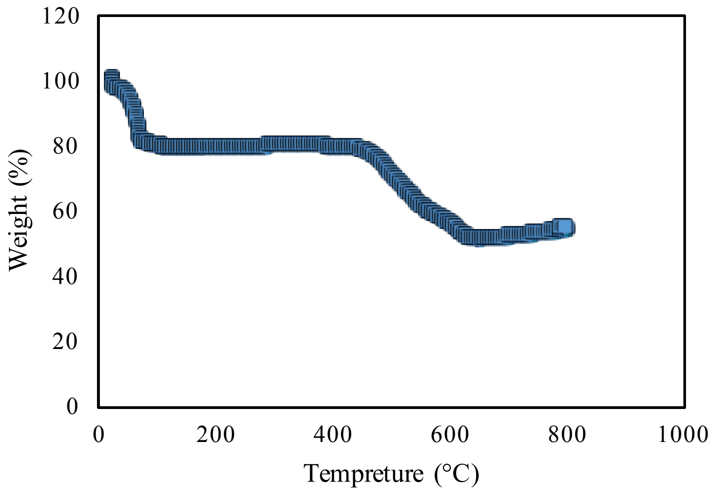


Figure 9: Thermogravimetric of AC-TiO_2 with MB..

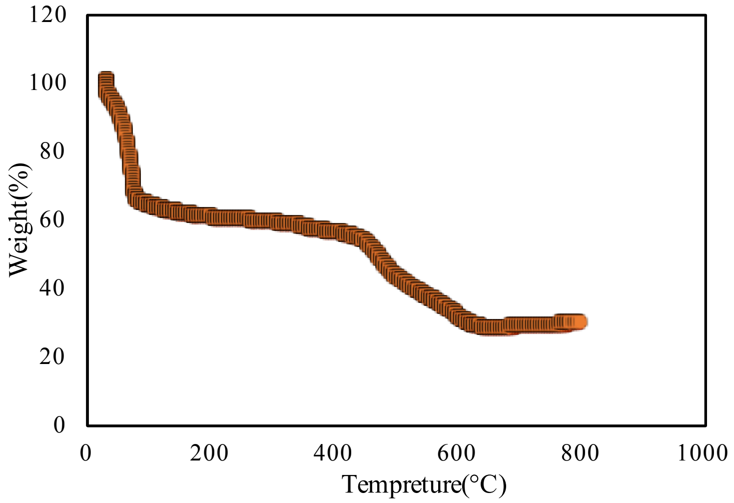


Figure 10: Thermogravimetric curves of AC-TiO_2 with ARS

TGA analysis (AC- Fe_3O_4)

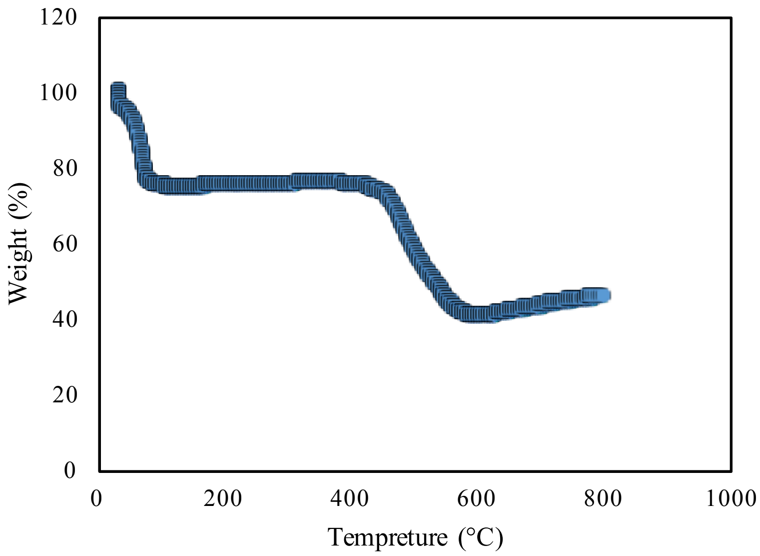


Figure 11: Thermogravimetric of AC- Fe_3O_4,MB

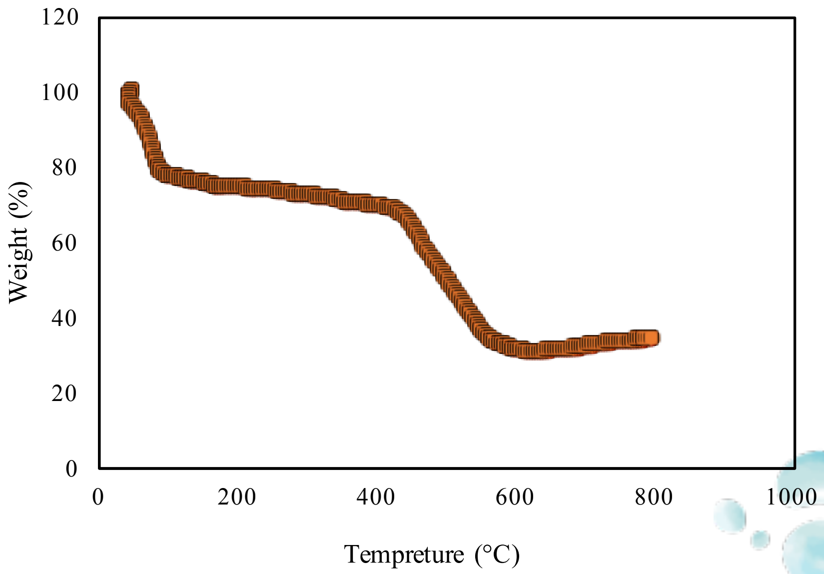


Figure 12: Thermogravimetric of AC- Fe_3O_4,ARS

Adsorption Parameters

1

pH. solution

2

Adsorbent dose

3

Dyes Concentration

1. pH solution (AC-TiO_2 vs. AC)

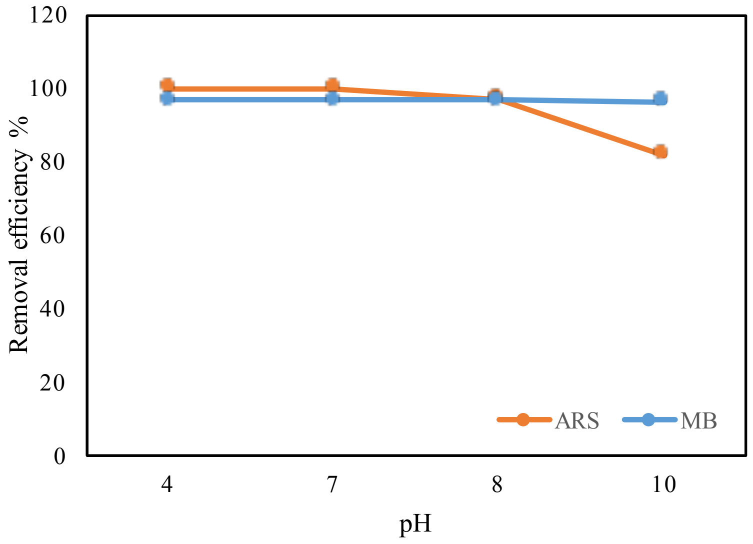


Figure 14: The pH. effect of AC-TiO_2 with ARS and MB dyes.

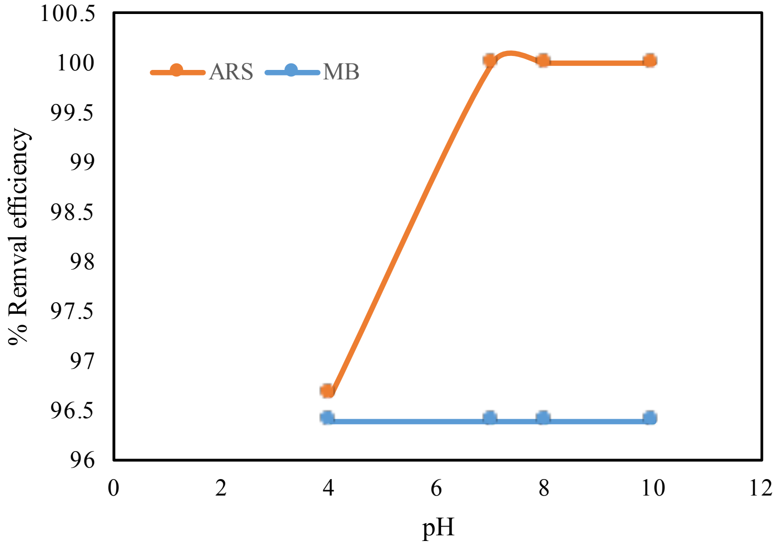


Figure 15: The pH. effect of AC with ARS and MB dyes.

Conditions

- 0.1 g adsorbent
- 10 ml dye solution
- 500 ppm concentration

2. Adsorbent dose (AC with MB).

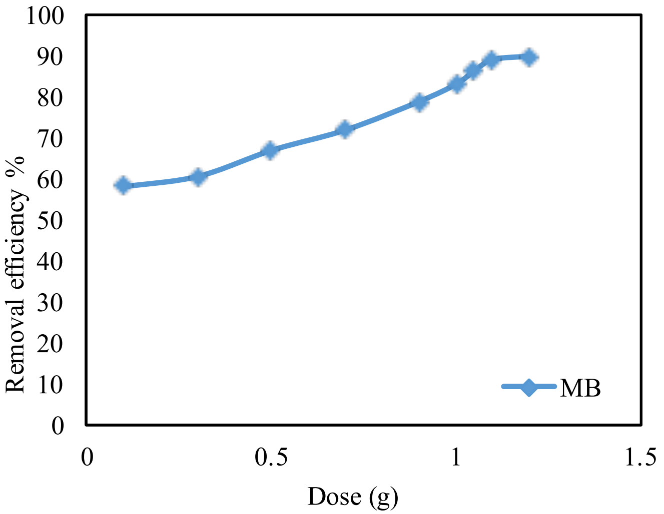
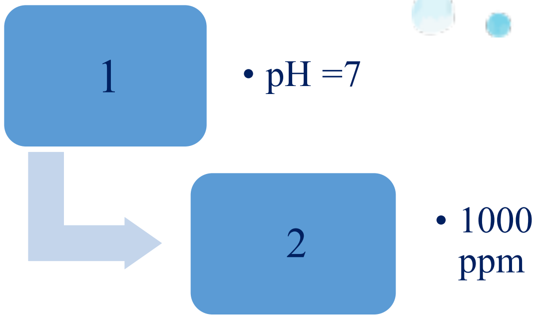


Figure 16: Effect of dosage of adsorbent on the removal of MB dye onto AC.

Conditions



3. Dyes concentration (AC)

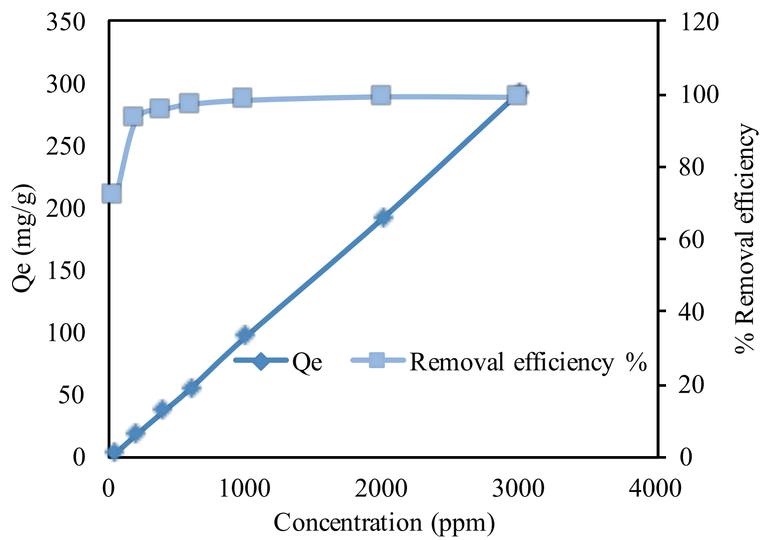


Figure 17: Effect of MB dye concentration on adsorption.

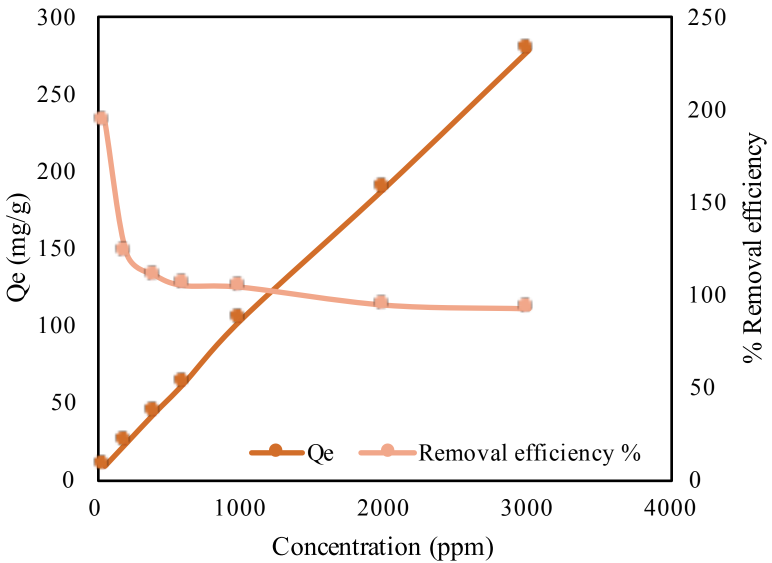


Figure 18: Effect of ARS dye concentration on adsorption.

Conditions

- 0.02 g adsorbent
- 10 ml dye solution
- 50-3000 ppm concentration
- pH =7

Kinetics study and Adsorption isotherm

Kinetics study

Lagergren’s model:

- Pseudo –first- order model which is generally expresses as

$$\frac{dq}{dt} = k_1 \times (q_e - q_t)$$

Where, k_1 is the first –order –rate constant .

- The kinetics rate expression can be written as :

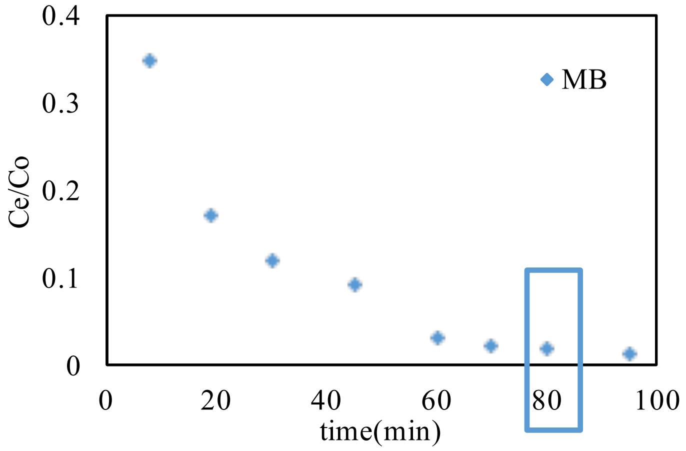
$$\log(q_e - q_t) = \log qe - \frac{k_1}{2.303} t$$

Y X

- Pseudo -second-order model which is expresses as

$$\frac{t}{qt} = \frac{1}{q_e} \times t + \frac{1}{k_2 \times q_e^2}$$

Y X



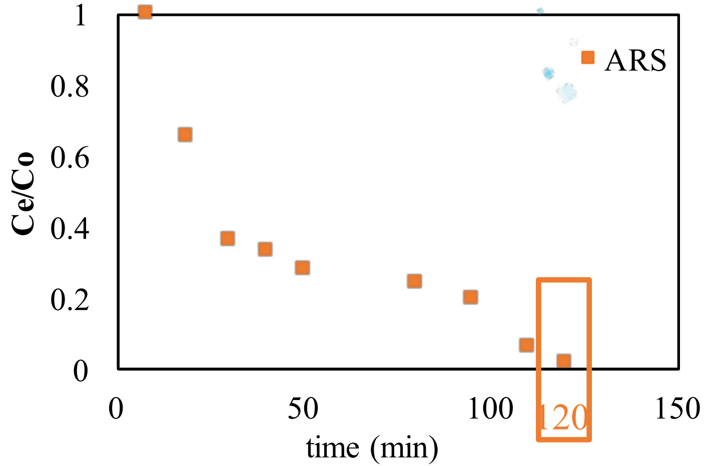
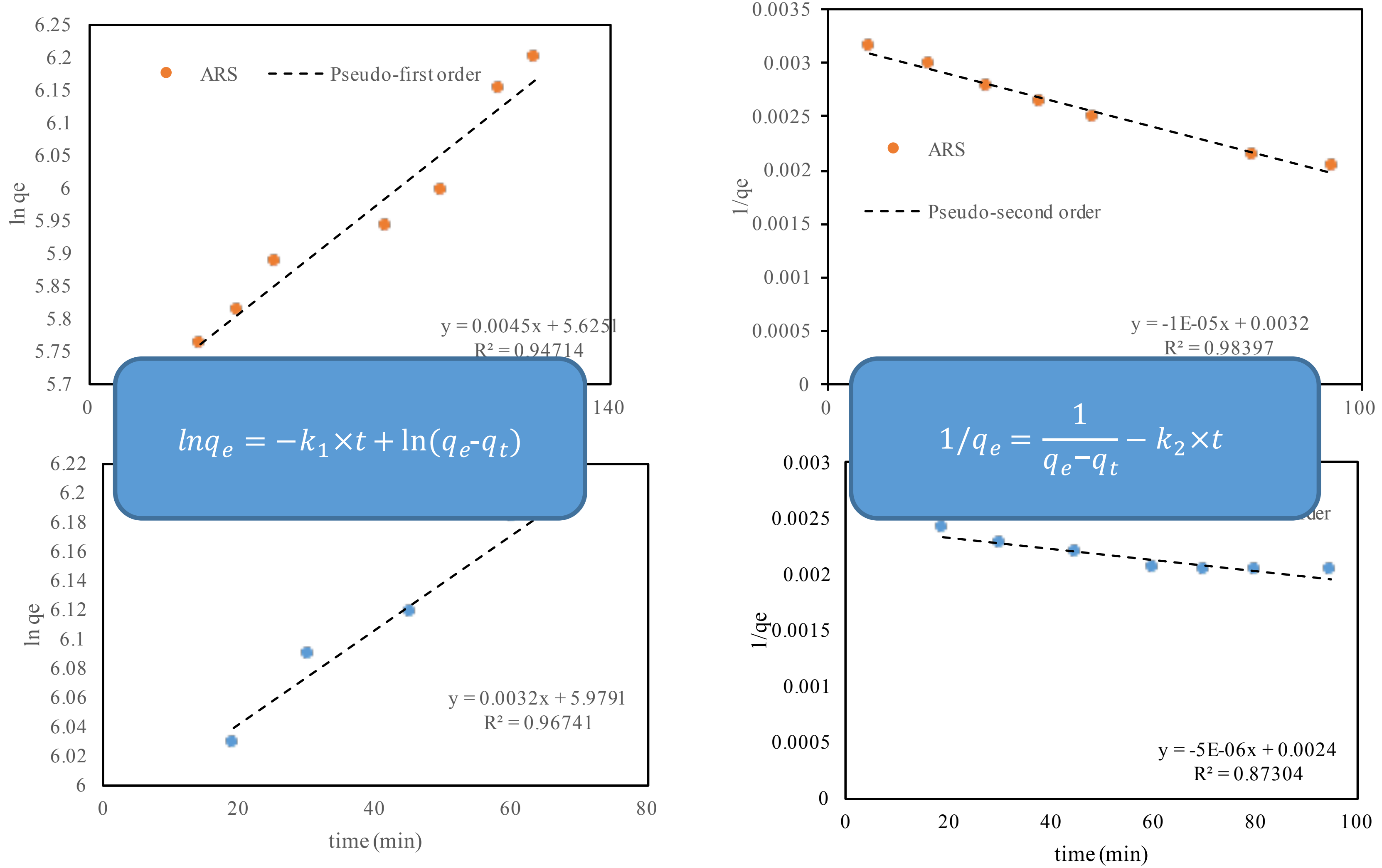


Figure 19: Adsorption kinetics of MB and ARS onto AC



$$lnq_e = -k_1 \times t + \ln(q_e\text{-}q_t)$$

$$1/q_e = \frac{1}{q_e - q_t} - k_2 \times t$$

Pseudo -first- order model for MB and ARS

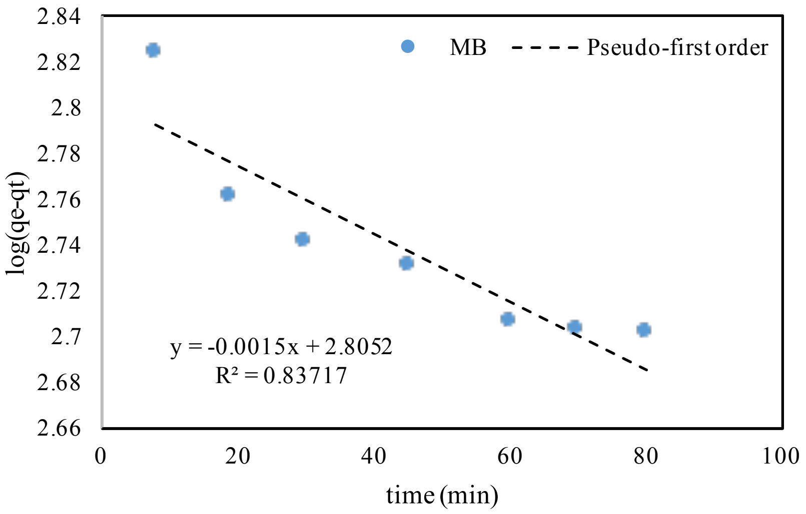


Figure 19: Pseudo-first-order kinetics for adsorption of MB by AC

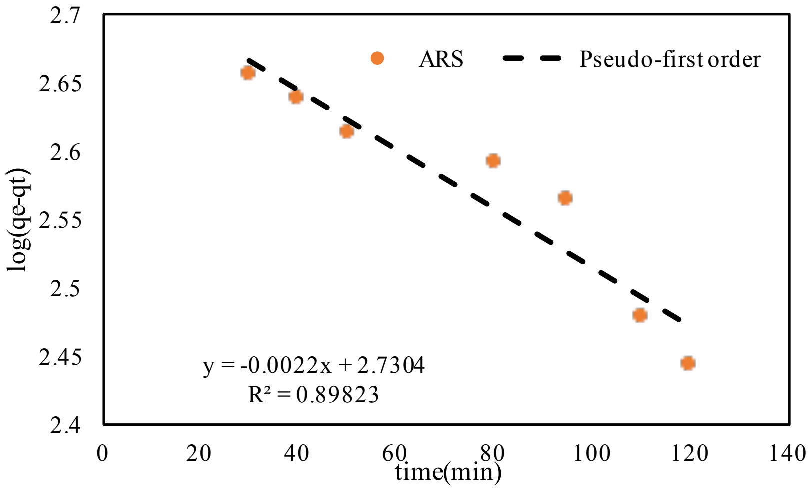


Figure 20: Pseudo-first-order kinetics for adsorption of ARS by AC

Pseudo -second- order model for MB and ARS

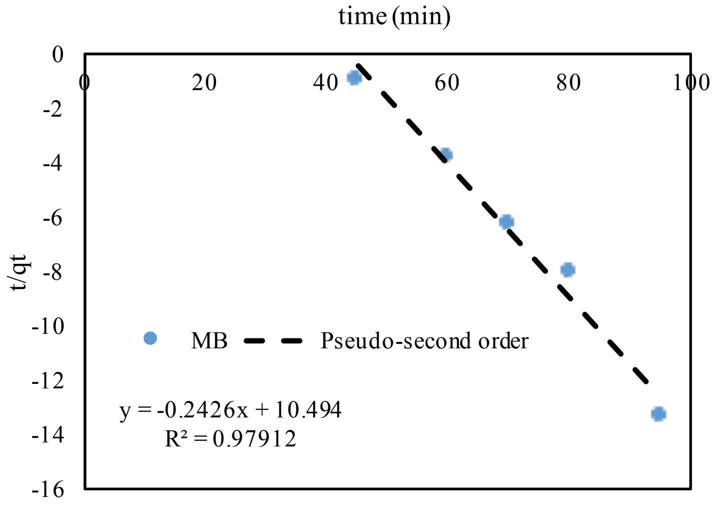


Figure 21: Pseudo-second-order kinetics for adsorption of MB by AC

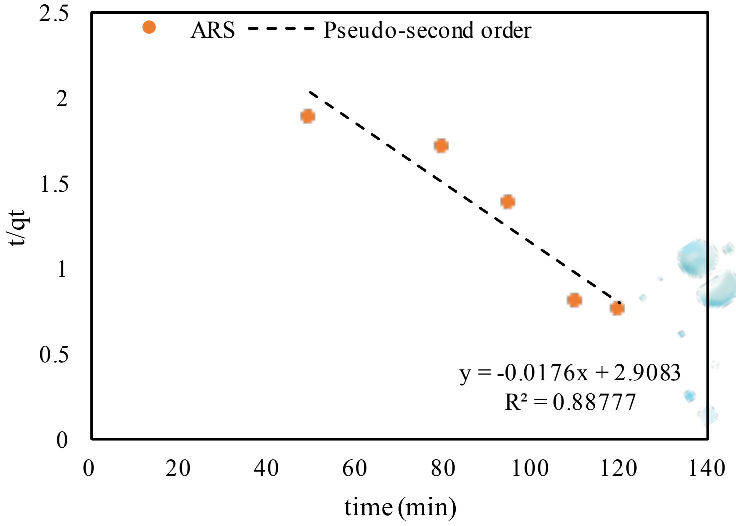


Figure 22: Pseudo-second-order kinetics for adsorption of ARS by AC

MB :pseudo second order
ARS : pseudo first order
Based on R^2

Adsorption isotherm

Model	Isotherm equation	applicability
Langmuir	$Qe = \frac{Qm(Ce \times K_L)}{1 + (Ce \times K_L)}$	Chemisorption and physical adsorption

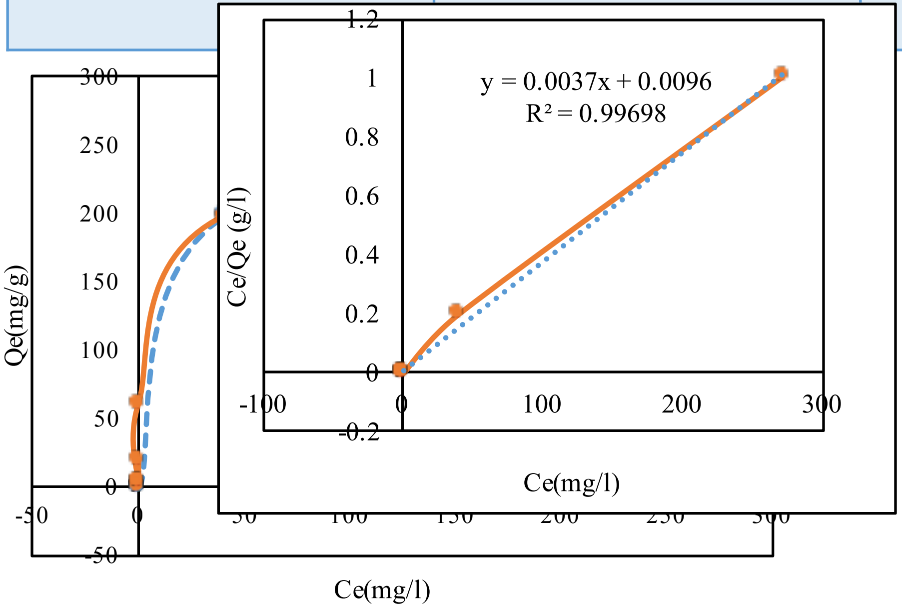


Figure 23: Equilibrium adsorption isotherm of Alizarin Red S onto activated carbon

- Adsorbate: AC
- Adsorbent dosage: 0.1 g
- Volume: 10 mL
- Temperature: 25 ℃
- Solution pH: 7
- Concentration: from 50 to 3000 ppm
- Mass balance equation:

$$Q_{e(exp)} = \frac{V\,(C_{\circ} - C_e)}{m}$$

Future Work and Recommendations

The future plan is to come up with a much better results by:

1. Study the competitive adsorption of binary aqueous mixtures of MB and ARS using AC.
2. Thermodynamic study.
3. Regeneration of AC.
4. Apply adsorbent in continuous system .
5. Apply adsorbent for real textile wastewater.

Conclusion

1. Based on characterization test the functional group was successfully immobilized on AC in particular FT-IR.

2. The results of this study concluded that the activated carbon was the most effective adsorbent in the removal of MB and ARS dye from synthesized wastewater.

3. The MB and ARS was successfully adsorbed by AC adsorbent and the removal efficiency was achieved a percent over 95 % .

Acknowledgment

Special thanks to Mrs. Maryam Hmoudah our supervisor for her effective help and positive energy in motivating to reach and achieve the project goals.

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THANK YOU !