

A simple, Efficient, and Rapid Method for Dyes removal from Wastewater using IDA-GO@Fe₃O₄ Magnetic Nanocomposite

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FTIR spectroscopy of GO, EDA-GO, and IDA-GO were reported by our group previously.¹ Briefly, the broad band at approximately 3320 cm⁻¹ (the O-H stretching vibration), the band at around 1732 cm⁻¹ (stretching vibration of the C=O bond of Carboxylic acid groups), and bands at 1224, and 1066 cm⁻¹ (stretching of C-OH, and of C-O bond, respectively) confirms the GO synthesis. After modification with EDA, a new band at 1656 cm⁻¹ (C=O bond of amide groups and additional bands attributed to the asymmetric stretching vibrations of C-N bonds, as well as the out-of-plane vibrations of NH₂ and NH, and the stretching vibrations of N-H confirms the structure. In the IDA-GO spectrum, a prominent band at 1743 cm⁻¹ indicates the presence of carboxylic acid groups. The absence of the 1547 cm⁻¹ band confirms the successful covalent bonding of acetic acid groups to EDA-GO and the transformation of primary amine groups into tertiary ones.

Also, EDA-GO and IDA-GO Raman spectra upon functionalizing graphene oxide with ethylenediamine (EDA-GO), the D and G peaks are observed at 1349 and 1584 cm⁻¹, respectively. The D/G ratio increases to 1.06, indicating the incorporation of *sp*³ hybridized carbon species onto the graphene oxide sheets. The D/G ratio for IDA-GO is 1.05, with D and G peaks at 1344 and 1576 cm⁻¹, respectively. This suggests suitable oxidation and successful functionalization of graphene oxide.¹

TGA analysis was reported in our previous report.¹ Briefly, the GO thermogram displays two distinct stages of weight loss, the first stage, corresponds to the degradation of CO₂-containing groups. The second stage, is attributed to the pyrolysis of the carbonaceous framework. In the EDA-GO thermogram, weight reduction begins at 200 °C and continues up to 800 °C. This gradual weight loss indicates an increase in hydrogen bonding between the functional groups in G-NH₂ compared to GO, due to the functionalization of graphene oxide sheets. Consequently, the remaining weight of EDA-GO is higher than that of GO. The IDA-GO thermogram demonstrates the pyrolysis of ethylenediamine and carboxylic acid groups at temperatures between 210 and 340 °C. Additionally, weight loss occurs between 340 and 450 °C due to the decomposition of the carbonaceous framework and the removal of organic groups from the IDA-GO surface.¹

Table S1 Thermodynamic parameters for MB and MO absorbed by IDA-GO/Fe₃O₄

	Freundlich			Langmuir		
	<i>n</i>	<i>K_f</i>	<i>R</i> ²	<i>K_L</i> (l/mg)	<i>R_L</i>	<i>R</i> ²
MB	9.40	260.20	0.7318	8.00	4.40×10 ⁻⁴	0.99
						60
MO	3.40	45.80	0.8973	0.30	2.50×10 ⁻²	0.99
						44

Table S2 Pseudofirst-order and pseudosecond-order kinetic parameters

	Pseudo-first-order model		Pseudo- second -order model					
	<i>q_e</i> (<i>exp</i>)	<i>q_e</i> (<i>cal</i>)	<i>K₁</i>	<i>R</i> ²	<i>q_e</i> (<i>exp</i>)	<i>q_e</i> (<i>cal</i>)	<i>K₂</i>	<i>R</i> ²
MB	200.00	35.40	1.60×10 ⁻²	0.9399	200.00	200.00	9.8×10 ⁻⁴	0.9999
MO	98.00	67.10	1.50×10 ⁻²	0.8834	98.00	105.20	3.6×10 ⁻⁴	0.9984

Reference

1 A. abdolmaleki, z. mohamadi, H. Fashandi, Z. Bazyar, Chemical Engineering Journal, 2024,**481**, 148622.