Track: AM

Low-Cost Biomodified Magnetite Nanoparticles for the Removal of Methylene Blue and Pb(II) ion from Simulated Wastewater

Chanchal Das[1*], Goutam Biswas[1] and Snehasis Bhakta[2]
[1]Department of Chemistry, Cooch Behar Panchanan Barma University, Cooch Behar, India.
[2]Department of Chemistry, Coochbehar College, Cooch Behar, India.
Co-author, Email: chanchaldas453@gmail.com, snehasis.bhakta1989@gmail.com
Corresponding author, Email: goutam@cbpbu.ac.in

Industrialization and increasing population in this era making serious impact on aquatic life as well as making 'water stress' to the human. To enhance the resources for drinkable water there is need to develop efficient and cheaper purification technology so that anyone can afford it. Though current purification technology is now in much advanced level, high cost and energy is the preferable thinking to avoid the use of them. In this context, a cheaper and efficient adsorbent for inorganic and organic pollutant is framed (Das et al., 2021). It has magnetite nanoparticles in its core and the surface is modified by the natural products (polyphenols, steroids, flavonoids etc.) coming from the *Terminalia arjuna* (TA) bark extract (aquas). The synthetic procedure is simple greener and done under room temperature, via co-precipitation. Production cost for the nanoparticles (NPs) was \$19.48/kg per day. It has saturation magnetization value of 50 emu g^{-1}, having sizes 43 nm [from high resolution transmission electron microscopy (HRTEM) analysis] and had 43.2% coating (from thermogravimetric analysis). The batch adsorption technique revealed that, the Langmuir maximum adsorption capacity (Q_m) for the removal of methylene blue (MB) and Pb(II) (as organic and inorganic pollutant) onto *Terminalia arjuna* bark extract coated magnetite nanoparticles (TA@MNPs), was 294.1 and 210 mg g^{-1} (**Table 1**). Adsorption process by the NPs obey pseudo-second-order kinetics and the physisorption behavior was also proven by the thermodynamic study. Desorption of the MB and Pb(II) by various eluents was also observed. Effect of various conditions was also applied to fine best adsorption result. From such low production cost and high efficiency to adsorb MB and Pb(II) ions, we can conclude that our nanoparticles might be used in industrial level to purify polluted surface water.

The results from the adsorption experiment can be summarized below:

- Highest adsorption occurred at pH 9, for MB and pH 3, for Pb(II).
- Maximum percentage of adsorption (equilibrium) achieved after 120 min (95%) for MB and after 514 min (61.2%) for Pb(II).
- Percentage of removal was increased with the increasing amount TA@MNPs for both the adsorbates.
- Percentage of adsorption was decreased with every 10 K rise of temperature.
- ΔG^o = -7.75 to -9.74 kJ mol^{-1} for MB and -0.3 to -1.62 kJ mol^{-1} for Pb(II) adsorption, which lies in the range, $0 > \Delta G^o < -20$ kJ mol^{-1}, hence the process is physisorption (Húmpola et al., 2013).
- Our low-cost nanoparticles are advantageous over other, as it is reproducible, thermally stable over 400 ℃ and superparamagnetic (absence of hysteresis loop in the alternating gradient magnetometry study), hence can be separable after wastewater treatment by applying magnetic field.

Table 1

A comparison for the maximum adsorption capacity (Q_m) of MB and Pb(II) on various magnetite nanoparticles (MNPs) based adsorbents.

	Adsorbents	**Q_m (mg g^{-1})**	**References**
For **Pb(II)**	TA@MNPs	210.5	Our study
	Cnidium monnieri (L.)Cuss-MNPs	105.6	(Lingamdinne et al., 2017)
	MDA-Fe_3O_4	333.3	(Jiryaei Sharahi and Shahbazi, 2017)
	Fe_3O_4 nanoparticles	36.0	(Nassar, 2010)
For **MB**	Fe_3O_4–multi wall carbon nanotubes	48.06	(Ai et al., 2011)
	Fe_3O_4@AC nanoparticles	138	(Joshi et al., 2019)
	Fe_3O_4 nanoparticles	70.4	(Giri et al., 2011)
	TA@MNPs	294.1	Our study

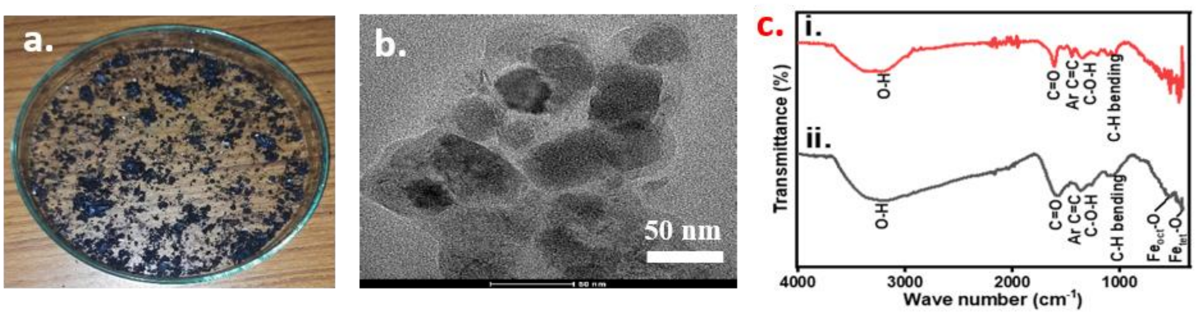

Fig. a. Solid TA@MNPs, b. HRTEM image, c. FTIR spectra of i. TA and ii. TA@MNPs**.**

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