Table SM1. EDXRF analyses of CSAC and MCSAC

Element	CSAC	MCSAC
P	2.62%	6.757%
K	939.76 ppm	958.69 ppm
Ca	1518.87 ppm	0.31 %
Fe	0.405 ppm	92.58 %
Cu	-	-
Zn	0.21%	-
Cl	-	0.25%

Table SM2. Description of equations used in the Manuscript

Equation/model name	Mathematical expression	Parameters	Equation no.
Helium density (ρ_{He}) measurement	$\rho_{Hg} = M/V_s$	M is the mass of sample, and V_s is the sample volume	**SM1**
	$\rho_{He} = M/V_s^{'}$	M is the mass of sample, $V_s^{'}$ is the sample volume inaccessible to helium.	**SM2**
Dubinin-Radushkevich equation	$\log W = \log W_0 - D\, log^2\left(\frac{p^0}{p}\right)$	W stands for micropore volume filled with liquid N_2 when the relative pressure is p/p^0 and W_0 is the total micropore volume. D stands for a characteristic constant for the microporous structure of the adsorbent	**SM3**
Total pore volume (V_T)	$V_T = \frac{1}{\rho_{Hg}} - \frac{1}{\rho_{He}}$	ρ_{Hg} and ρ_{He} are mercury and helium densities	**SM4**
Pseudo-first-order rate equation (linear)	$\ln\left(\frac{q_e - q_t}{q_e}\right) = -k_1 t$	q_e is the equilibrium adsorption capacity, q_t is the adsorption capacity at time 't', k_1 is the rate constant, t is time	**SM5**
Pseudo-first-order rate equation (non-linear)	$q_t = q_e\left(1 - e^{-k_1 t}\right)$	q_e is the equilibrium adsorption capacity, q_t is the adsorption capacity at time 't', k_1 is the rate constant, t is time	**SM6**

Pseudo-second-order rate equation (linear)	$\frac{t}{q_t} = \frac{1}{k_2\, q_e^2} + \frac{t}{q_e}$	t = time, k_2 is pseudo-second-order adsorption rate constant (g mg^{-1} min^{-1}), q_e is the amount of 2-NP adsorbed at equilibrium and q_t the amount of 2-NP adsorbed at time "t".	**SM7**
Freundlich isotherm model	$q_e = K_F C_e^{1/n}$	q_e is the 2-NP amount adsorbed per unit weight of adsorbent (mg/g), K_F and 1/n are constants, C_e is the equilibrium 2-NP concentration	**SM8**
Langmuir isotherm model	$Q_e = \frac{Q^0 b C_e}{1 + bC_e}$	q_e is the 2-NP amount adsorbed per unit weight of adsorbent (mg/g), C_e is the 2-NP equilibrium concentration in solution (mg/L), Q^0 is the monolayer adsorption capacity (mg/g) and constant b is related to the net enthalpy, H, of adsorption ($b \propto e^{-\Delta H/RT}$). More precisely, "b" is the reciprocal of concentration at which half saturation is attained.	**SM9**
Sips isotherm model	$Q_e = \frac{K_{LF} C_e^{n_{LF}}}{1 + (a_{LF} C_e)^{n_{LF}}}$	K_{LF}, a_{LF} and n_{LF} are the Sips constants	**SM10**

Table SM3. Fixed-bed column parameters and equations used for 2-NP removal by CSAC

Equation	**Parameters**	**Equation No.**
$t_x = \frac{\bar{V}}{F_m}$	F_m is the mass flow rate expressed as mass per unit cross-sectional bed	**SM11**
$t_\delta = \frac{\bar{V}_x - \bar{V}_b}{F_m}$	$\bar{V}_x$, is the total effluent mass quantity per unit adsorbent area when adsorbent is approaching saturation, $\bar{V}_b$ is total effluent mass quantity per unit adsorbent area at breakpoint, F_m is the mass flow rate expressed as mass per unit cross-sectional bed	**SM12**
$\frac{\delta}{D} = \frac{t_\delta}{t_x - t_b}$	D is the ratio of carbon bed depth, t_b is the time required for initial PAZ formation, t_δ is the time required for the zone moving down to its own length in the column, t_x is the total time consumed by the primary adsorption zone establishment	**SM13**
$f = 1 - \frac{t_b}{t_\delta}$	f is the fractional capacity	**SM14**
$\delta = D\left(1 - \frac{t_b}{t_x}\right)$	δ is the length of the primary adsorption zone, D is the ratio of carbon bed depth, t_x is the total time consumed by the primary adsorption zone establishment	**SM15**
Percent Saturation = $\frac{D + \delta(f-1)}{D} * 100$	-	**SM16**
Bed Volume = $\frac{Weight\ of\ Carbon\ (Kg)}{Carbon\ bulk\ density\ (Kg/m^3)}$	-	**SM17**
EBCT = $\frac{Bed\ volume}{Flow\ rate}$	-	**SM18**
Carbon usage rate (Kg/L) = $\frac{Weight\ of\ carbon\ in\ columg\ (g)}{Volume\ of\ breakthrough\ (L)}$	-	**SM19**

* 1000		

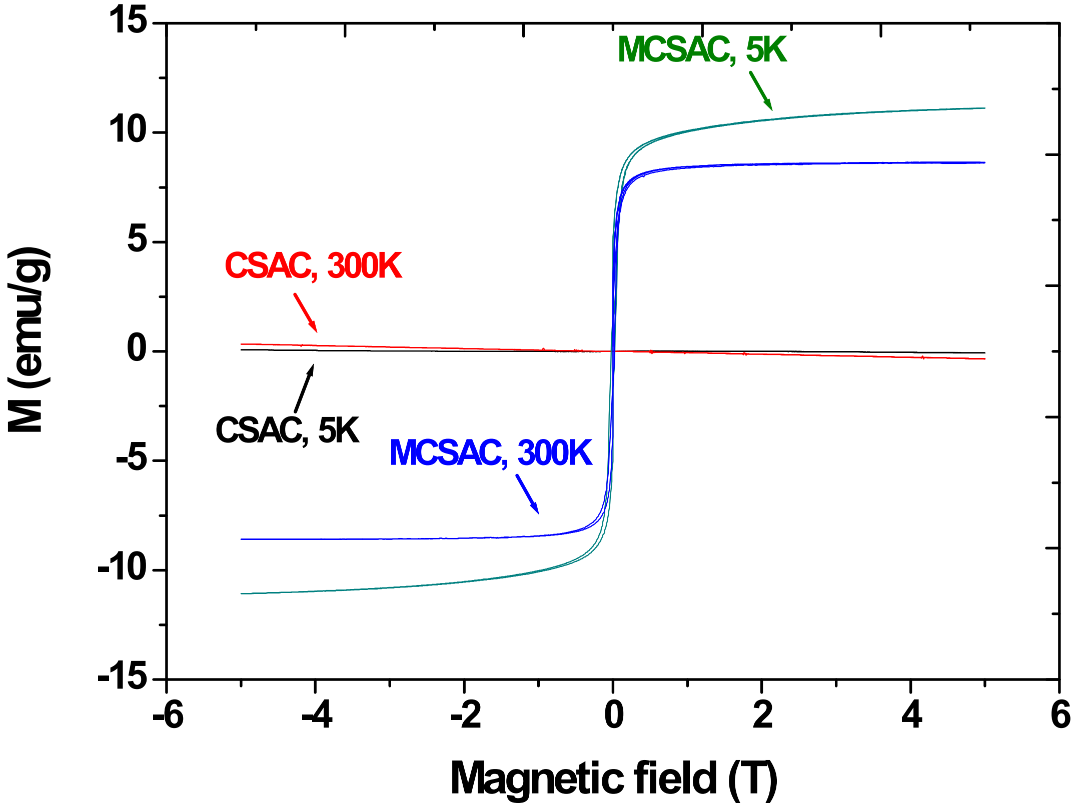
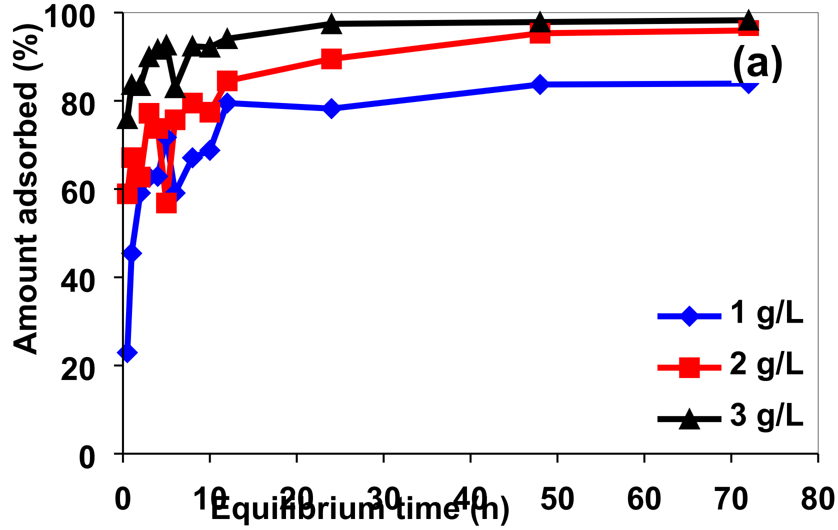


Figure SM1. Hysteresis loops of CSAC and MCSAC at 5 and 300 K.



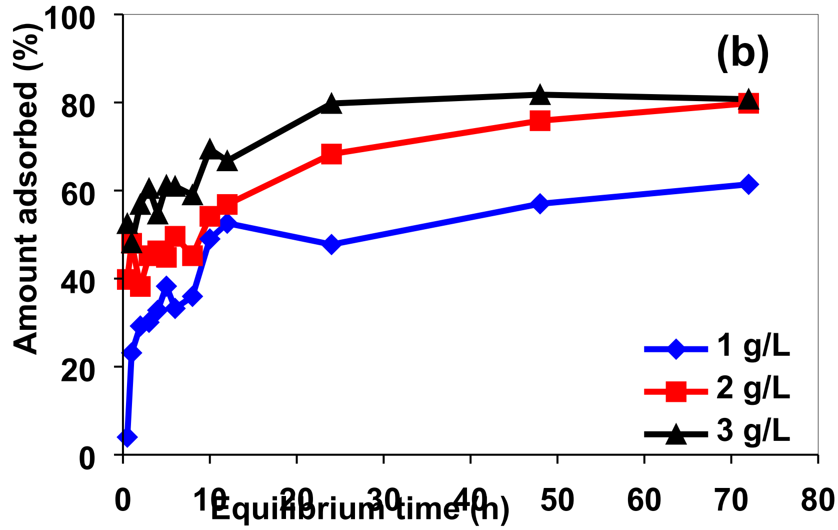
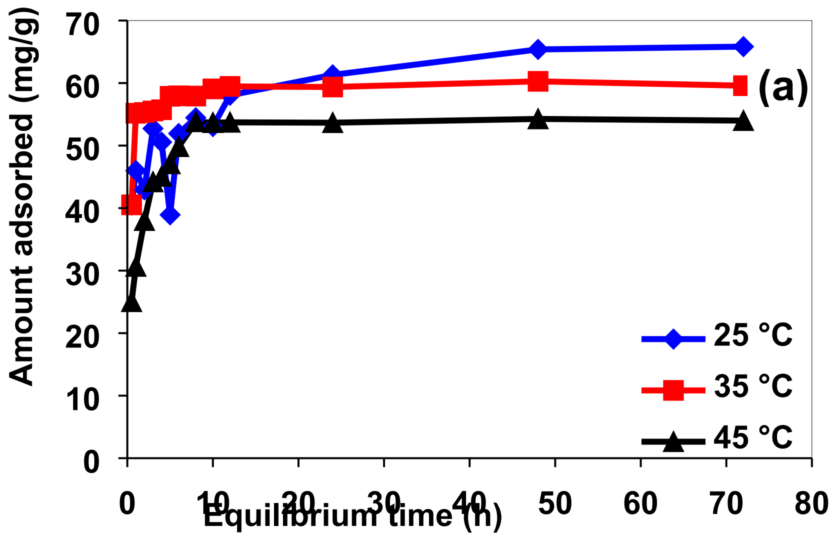


Figure SM2. Effect of adsorbent dose on 2-NP adsorption by (a) CSAC and (b) MCSAC [pH 4.0; 2-NP concentration= 1×10^{-3} M; temperature= 25 ºC; particle size= 50-100 B.S.S mesh]



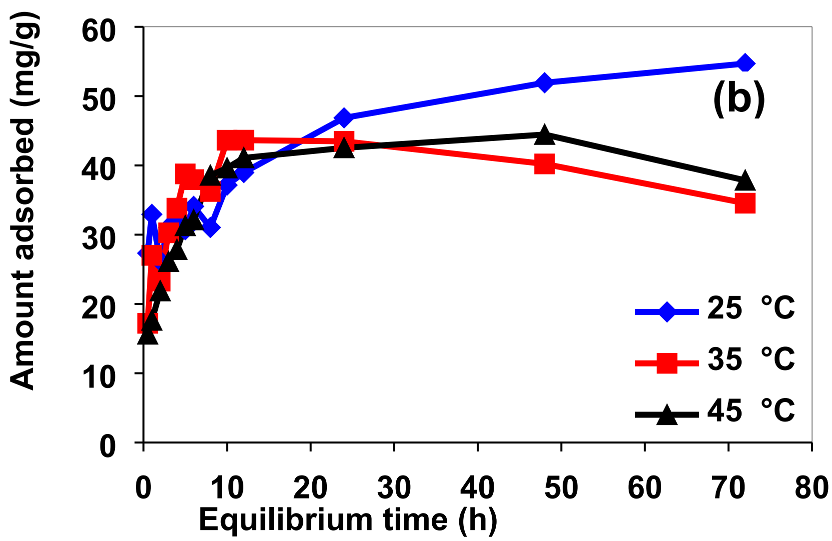


Figure SM3. **Effect of temperature on 2-NP adsorption by (a) CSAC and (b) MCSAC [pH 4.0; 2-NP concentration= 1x10^{-3} M; adsorbent dose= 2 g/L; particle size= 50-100 B.S.S mesh]**

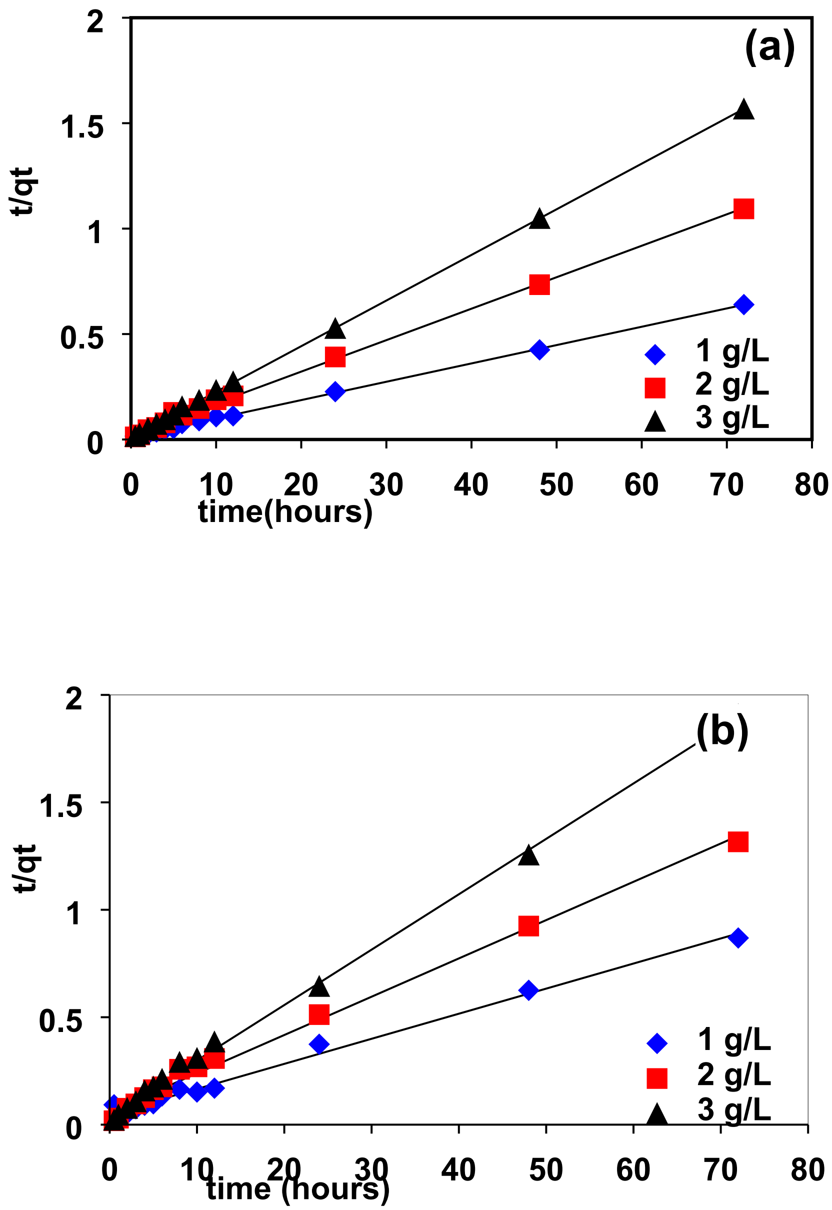
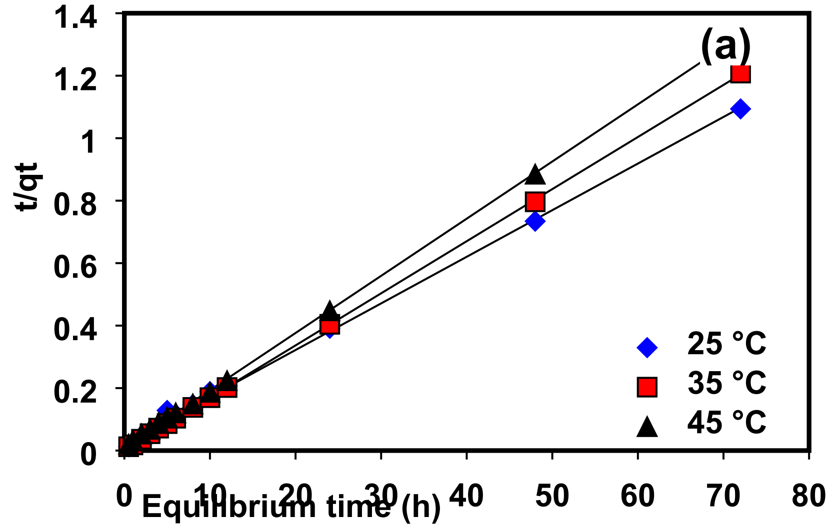


Figure SM4. **Pseudo-second-order kinetic plots for 2-NP removal by (a) CSAC and (b) MCSAC at adsorbent dose [initial 2-NP concentration = 1×10^{-3} M; pH = 4.0, adsorbent dose = 2 g/L; particle size = 50-100 B.S.S. mesh]**



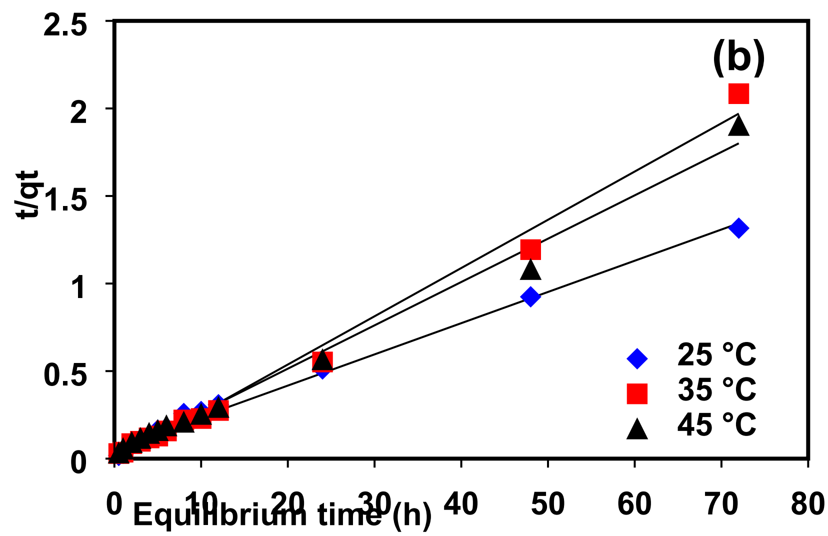


Figure SM5. Pseudo-second-order kinetic plots for 2-NP removal by (a) CSAC and (b) MCSAC at different temperatures [initial 2-NP concentration = 1×10^{-3} M; pH = 4.0, adsorbent dose = 2 g/L; particle size = 50-100 B.S.S. mesh]

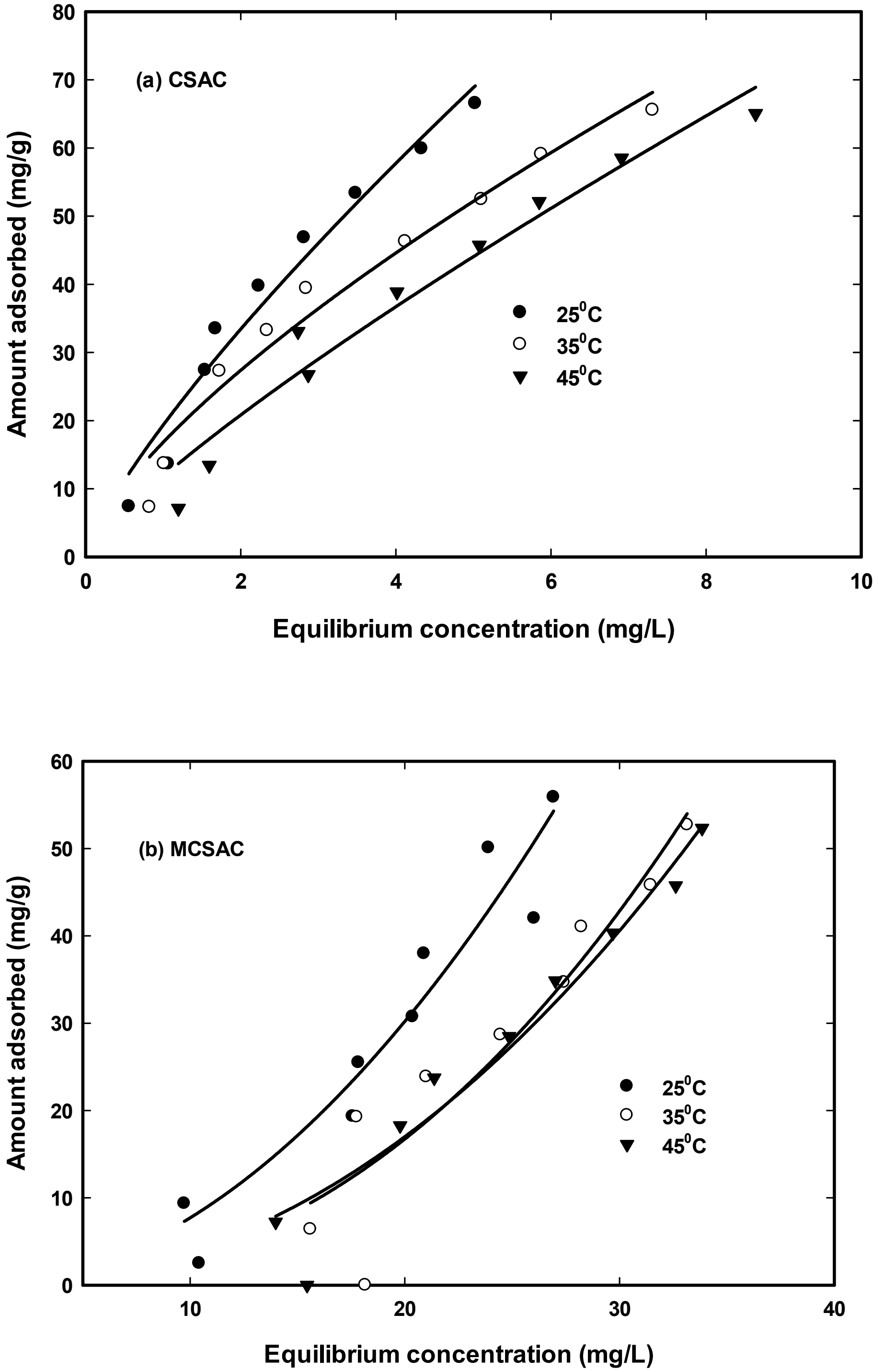


Figure SM6. Freundlich adsorption isotherm of 2-NP by CSAC at different temperatures [pH= 4.0; initial 2-NP concentration range= 1x10^{-4}-1x10^{-3} M; adsorbent concentration= 2 g/L; particle size= 50-100 B.S.S. mesh]

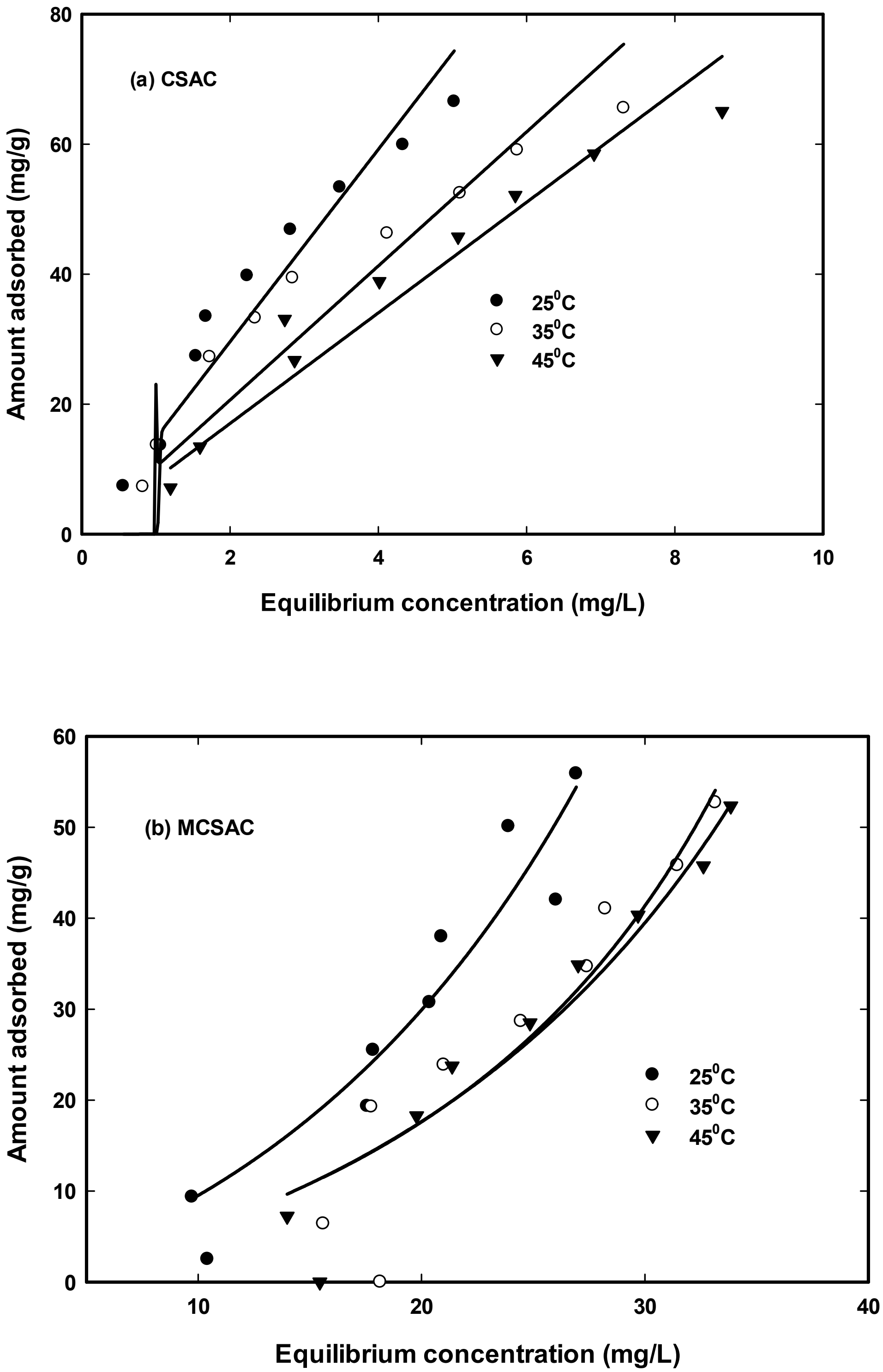


Figure SM7. Redlich Peterson adsorption isotherm of 2-NP by CSAC at different temperatures [pH= 4.0; initial 2-NP concentration range= $1x10^{-4}$-$1x10^{-3}$ M; adsorbent concentration= 2 g/L; particle size= 50-100 B.S.S. mesh]

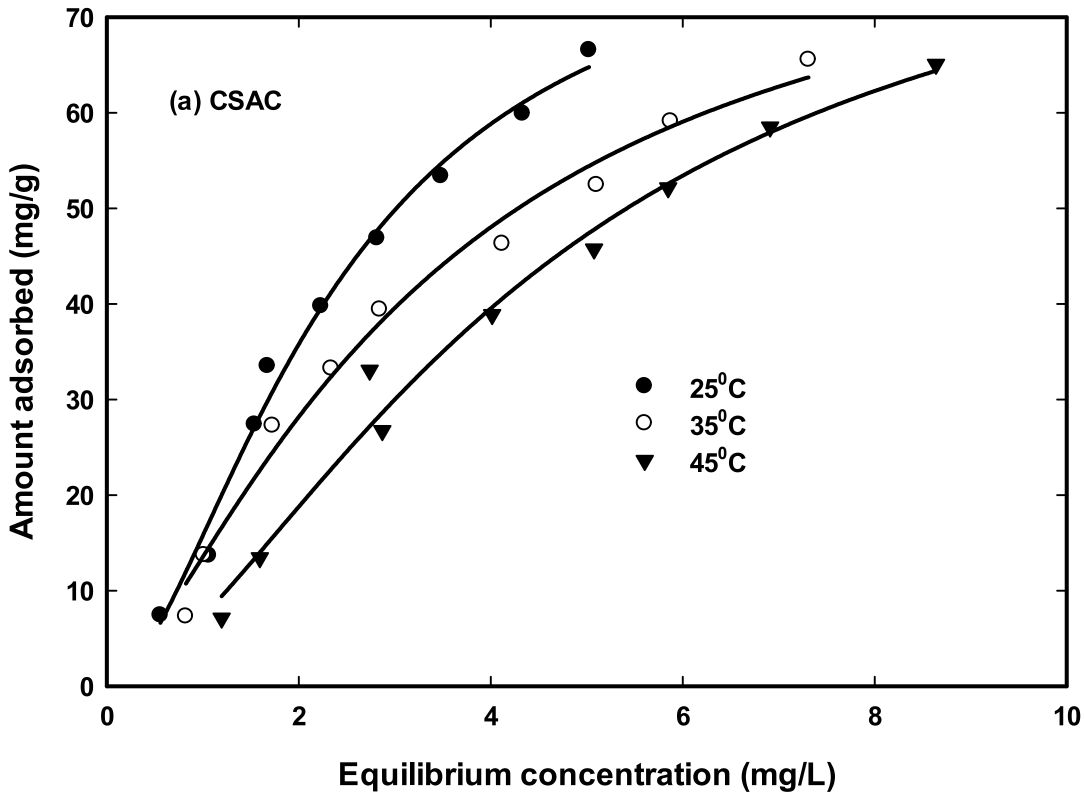


Figure SM8. Koble adsorption isotherm of 2-NP by CSAC at different temperatures [pH= 4.0; initial 2-NP concentration range= $1x10^{-4}$-$1x10^{-3}$ M; adsorbent concentration= 2 g/L; particle size= 50-100 B.S.S. mesh]

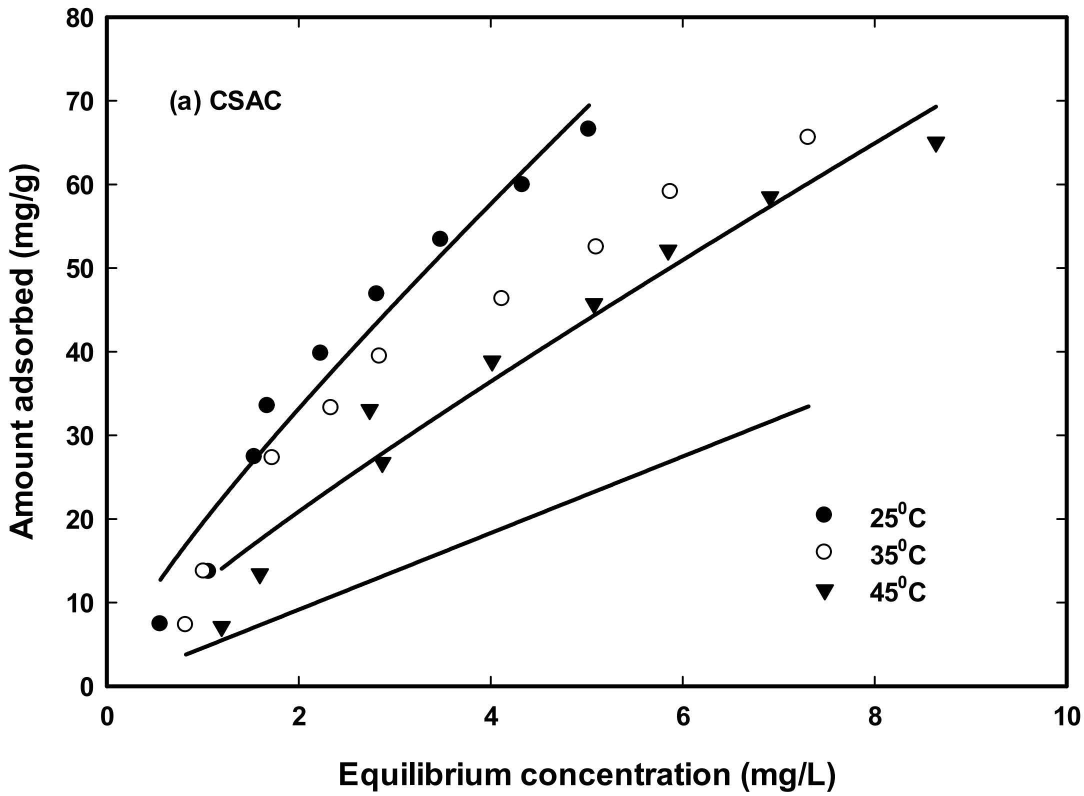


Figure SM9. Toth adsorption isotherm of 2-NP by CSAC at different temperatures [pH= 4.0; initial 2-NP concentration range= $1x10^{-4}$-$1x10^{-3}$ M; adsorbent concentration= 2 g/L; particle size= 50-100 B.S.S. mesh]

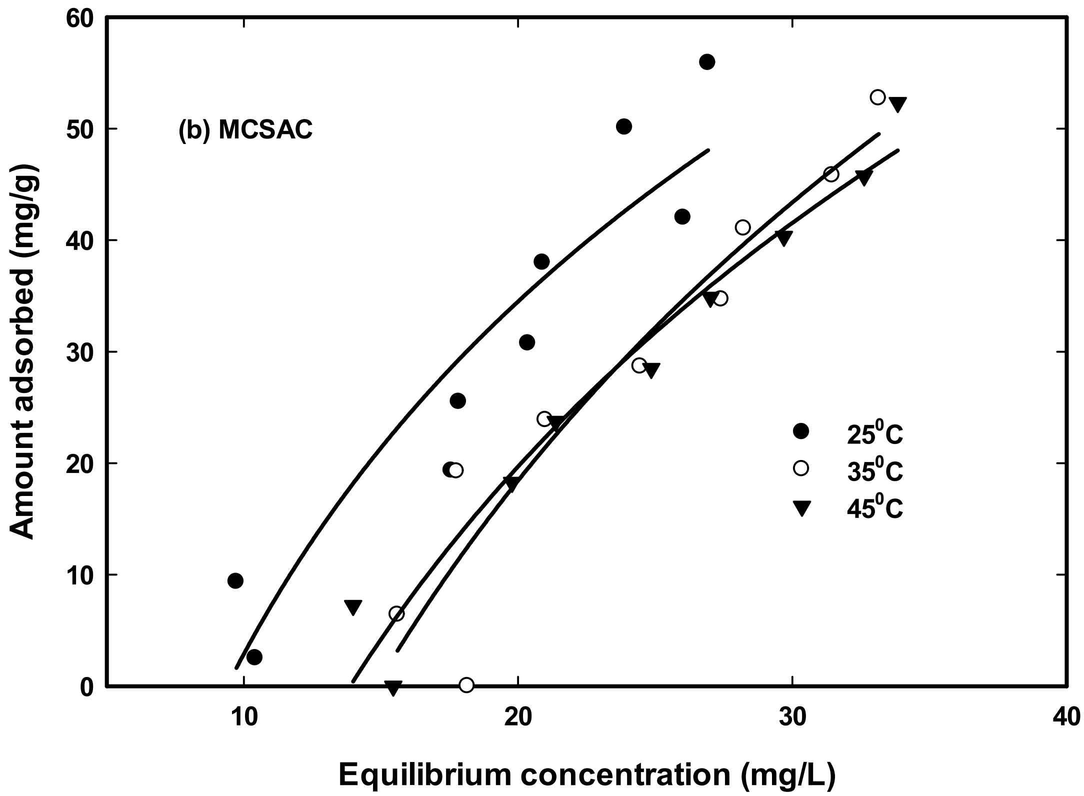


Figure SM10. Temkin adsorption isotherm of 2-NP by CSAC at different temperatures [pH= 4.0; initial 2-NP concentration range= $1x10^{-4}$-$1x10^{-3}$ M; adsorbent concentration= 2 g/L; particle size= 50-100 B.S.S. mesh]