

Electronic Supplementary Material

Beta-cyclodextrin adsorbents to remove water pollutants—a commentary

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Table S1 Synthesis strategies of β -CD-based adsorbents.

Class of adsorbent	Adsorbent	Preparation	Reference
Crosslinked β -CD-based adsorbent	Citric acid crosslinked β -CD	<ul style="list-style-type: none">• 6 g of dried β-CD, 3 g of anhydrous citric acid, 1.5 g of monopotassium phosphate, and 135 mL of distilled water were mixed.• The mixture was dried in an oven at 140 °C for 3.5 h.• The crude product was washed, filtered, and dried.	[5]
	Citric acid crosslinked β -CD	<ul style="list-style-type: none">• 6 g of dried β-CD, 3 g of anhydrous citric acid, 1.5 g of monopotassium phosphate, and 135 mL of distilled water were mixed.• The mixture was dried in an oven at 140 °C for 3.5 h.• The crude product was washed, filtered, and dried at 50 °C.• 10 g of sulphuric acid and 10 g of the product were added to the toluene and refluxed at 80 °C for 6 h.• The solid was separated, washed, and dried in an oven.	[4]
	Citric acid-crosslinked β -CD	<ul style="list-style-type: none">• 3 g of citric acid, 6 g of β-CD, 1.5 g of monopotassium phosphate, and 135 mL of ultrapure water were mixed and stirred.• The mixture was heated in an oven at 140 °C for 3.5 h.• The mixture was cooled, and the product was purified by soaking in 500 mL of water for 5 times.• The product was filtered and dried at 50 °C.	[3]
	Citric acid-crosslinked β -CD	<ul style="list-style-type: none">• β-CD, polyethylene glycol 400, citric acid monohydrate, sodium dihydrogen phosphate, and deionized water were mixed and stirred in a boiling water bath.• The mixture was transferred into a culture dish and heated at 140 °C for 4 h in an electric thermostatic oven.• The crude product was naturally cooled, weighed, and ground.• The granules were purified several times with deionized water, filtered, and dried at 50 °C.	[30]
	Citric acid-crosslinked β -CD	<ul style="list-style-type: none">• 10 g of β-CD, 5 g of citric acid monohydrate, 0.5 g of sodium dihydrogen phosphate, 1 g of poly (vinyl alcohol) 1799, and 50 mL of deionized water were mixed and stirred in boiling water bath.	[23]

- | | | |
|---|---|------|
| Crosslinked β -CD polymer | <ul style="list-style-type: none"> • The mixture was transferred into a culture dish, and heated in an oven at 140 °C for 4 h. • The mixture was naturally cooled. • The crude product was weighed and grinded into fine granulae. • The granulae were purified, filtered, and dried at 50 °C. • Add 11.1 g of β-CD, 4.95 g of 4,4'-difluorodiphenylsulfone, 20 mL of toluene and 80 mL of dimethylacetamide were added into a three-neck round flask. • 8.07 g of potassium carbonate was added and the solution was stirred at 150 °C for 12 h under nitrogen atmosphere. • The solution was slowly dropped into water/ethanol (volume ratio: 1:1) solution. • The precipitates were recovered by centrifugation and washed several times. • The crosslinked polymer was dried at 60 °C for 12 h. | [29] |
| Amphoteric β -CD-based adsorbent | <ul style="list-style-type: none"> • 2 g of citric acid crosslinked β-CD and 2 g of potassium persulfate were soaked in 400 mL deionized water. • The mixture was stirred at 80 °C for 30 min. • 10 mL of 2-dimethylamino ethyl methacrylate monomer was added to the mixture. • The solution pH was adjusted to neutral using 1 mol/L hydrochloric acid and stirred at 80 °C for 3 h. • The product was collected by suction filtration, washed five times, and dried at 45 °C for overnight. | [32] |
| Crosslinked sawdust- β -CD polymers | <ul style="list-style-type: none"> • 60-80 mesh of sawdust was rinsed with deionized water, and dried at 105 °C for 24 h. • 2 g of sawdust, 5 g of β-CD, 3 g of citric acid, and monosodium phosphate were mixed with 50 mL of deionized water, and subjected to sonic oscillation for 20 min. • The mixture was cured at 160 °C for 15 min. • The solid was washed with warm water and alcohol. • The sample was dried at 105 °C. | [62] |
| Crosslinked 1,2,3,4- | <ul style="list-style-type: none"> • 2.27 g of β-CD was dissolved in 20 mL of pyridine and stirred. • 1, 2, 3, 4-butanetetracarboxylic dianhydride was added to the solution. | [35] |

butanetetracarboxylic dianhydride/ β -CD	<ul style="list-style-type: none"> • The mixture was stirred at 40-150 °C for 24 h. • The mixture was cooled, poured into a solution of 80 mL of acetone and 20 mL of 5 % acetic acid, and stirred for 30 min. • The precipitate was washed three times, dried at 60 °C for 24 h in a vacuum oven, and passed through a 100-mesh sieve. 	
Ethylenediaminetetraacetic acid-crosslinked β -CD	<ul style="list-style-type: none"> • 4 g of dried β-CD, 6 g of EDTA, 2.68 g of sodium dihydrogen phosphate, and 20 mL of deionized water were mixed and stirred at 100 °C for 1 h. • Polyethylene glycol 200 was added dropwise to the solution. • The mixture was transferred into a Petri dish and heated in an oven at 155 °C for 10 h. • The mixture was cooled, the product was ground, and soaked with 500 mL of deionized water. • The product was filtered and rinsed with a large amount of 0.1M hydrochloric acid, deionized water, and 0.1M sodium hydroxide. • The product was dried in a vacuum at 60 °C for overnight. 	[12]
β -CD-derived polymer networks	<ul style="list-style-type: none"> • 15.0 g β-CD was dissolved in 150 mL methanesulfonic acid and pre-reacted for 45 min with bath sonication. • The solution was then heated and maintained at 110 °C for 48 h. • The solution was cooled in an ice bath and quenched with water. • The solid was collected and washed with copious amounts of water. • Soxhlet extraction by water was then conducted for 24 h to remove un-crosslinked low molecular weight material. • The solid was dried in a vacuum oven at 80 °C for 24 h. • The dried solid was then ground into a fine powder with a coffee grinder. 	[36]
4,4'-(hexafluoroisopropene) diphthalic acid-crosslinked β -CD	<ul style="list-style-type: none"> • The amounts of 4,4'-(hexafluoroisopropene) diphthalic acid and β-CD (molar ratio, 3:1) were weighed and added into a 600 mL beaker. • 0.25 g of potassium dihydrogen phosphate and 100 mL of deionized water were added • The mixture was oven-dried at 140 °C for 3.5 h. • The material was repeatedly rinsed with deionized water and oven-dried. 	[37]
β -CD/	<ul style="list-style-type: none"> • 0.41 g of β-CD, 0.20 g of tetrafluoroterephthalonitrile and 0.64 g of potassium 	[38]

	tetrafluoroterephthalonitrile	<p>carbonate were added into a 48 mL pressure vessel.</p> <ul style="list-style-type: none"> • 16 mL solution mixture of tetrahydrofuran/N,N-dimethylformamide (v/v, 9:1) was added under nitrogen atmosphere. • The vessel was sealed and magnetic stirred for 48 h at 60 °C and 500 rpm/min. • The orange suspension was cooled to room temperature and filtered. • The residual of potassium carbonate was neutralized with 1 M hydrochloric acid. • The rest of solid product on filter paper was soaked in water (1 × 10 mL) for 15 min, tetrahydrofuran (2 × 10 mL) for 30 min and dichloromethane (1 × 15 mL) for 15 min. • The product was dried in a vacuum freeze dryer for 24 h. 	
Porous β -CD-based adsorbent	Hyper-crosslinked β -CD	<p><i>Benzylated β-CD</i></p> <ul style="list-style-type: none"> • 500 mg of β-CD dissolved in 10 mL of anhydrous N,N-dimethylformamide. • The solution was cooled to 0 °C and 740 mg of 60 % sodium hydride was added under nitrogen atmosphere. • The solution was stirred for 15 min, 2.20 mL of benzyl bromide was slowly added, and the mixture was warmed to room temperature. • The mixture was stirred for 24 h, and 5 mL of methanol was added. • The residue was diluted with 100 mL of water, and extracted with 3×50 mL of methylene chloride. • The combined organic layers were washed, dried with anhydrous sodium sulphate, filtered, and concentrated using rotary evaporators. • The product was purified by silica gel chromatography (n-hexane to ethyl acetate, 8:1). <p><i>Hyper-crosslinked β-CD porous polymer</i></p> <ul style="list-style-type: none"> • 0.46 g of benzylated β-CD and 1.10 g of dichloroethylene were dissolved in 1,2-dichloroethane. • 1.03 g of iron (III) chloride was slowly added under nitrogen atmosphere. • The mixture was fitted with a condenser and heated to 80 °C for 24 h. • The mixture was cooled, the brown precipitate was recovered by filtration, washed until the filtrate became colourless, and purified by Soxhlet extraction with methanol for 24 h. 	[31]

	Porous β -CD polymer	<ul style="list-style-type: none"> • The product was dried under vacuum at 50 °C for 24 h. • A flame dried 20 mL scintillation vial was charged with 0.2 g of β-CD, 0.1 g of tetrafluoroterephthalonitrile, and 0.3 g of potassium carbonate. • The vial was flushed with nitrogen gas for 5 min, and 8 mL of dry tetrahydrofuran was added. • The vial was bubbled with nitrogen gas for 2-3 min. • The nitrogen gas was removed, and the mixture was stirred at 85 °C, 500 rpm for 48 h. • The suspension was cooled, filtered, and the residual potassium carbonate was washed on a filter paper. • The solid was soaked in 20 mL of water for 15 min, 20 mL of tetrahydrofuran for 30 min, and 15 mL of dichloromethane for 15 min. • The solid was dried in a liquid nitrogen bath at -196 °C for 10 min and then at 25 °C for 48–72 d. 	[43]
Grafted/imprinted β -CD-based adsorbent	Ethylenediaminetetraacetic acid-crosslinked β -CD polymer grafted onto Fe-Al hydroxides	<p><i>Fe-Al bimetallic hydroxides (co-precipitation)</i></p> <ul style="list-style-type: none"> • 0.1 M Iron (III) chloride and aluminium chloride (v/v, 1:1) were mixed, heated in a water bath at 65 °C for 30 min. • 1 M sodium hydroxide was added to the mixture, stirred for 30 min and solution pH was maintained to 7.0-7.4. • The mixture was allowed to stand for 4-10 h. • The supernatant was drained and the sediment was dried in an oven at 60 °C. • The solid was washed three times, oven-dried, and grounded to pass through 100-mesh screen. <p><i>Fe-Al hydroxides coated with ethylenediaminetetraacetic acid-crosslinked β-CD</i></p> <ul style="list-style-type: none"> • 4 g of β-CD, 1 g of Fe-Al bimetallic hydroxides, and 0.5 g of polyethylene glycol 200 were dissolved in a 20 mL of 0.01 M sodium hydroxide solution. • The mixture was vibrated by ultrasonic oscillation for 15 min. • The mixture was stirred in water bath at 60 °C for 20 min. • 5 g of ethylenediaminetetraacetic acid was added to the mixture and stirred until the formation of a thick sol-like substance. • The solution was poured into a polytetrafluoroethylene reactor and reacted at 	[13]

β -CD grafted silica gel

160 °C for 24 h.

- The product was washed, dried in an oven, and ground in a mortar.

Mono[6-O-(p-toluenesulfonyl)]- β -CD

- 6 g of sodium hydroxide in 20 mL water was added dropwise to a 56.8 g of β -CD in 500 mL water and stirred at 10-15 °C for 15 min.
- 11.4 g of p-toluenesulfonyl chloride in 30 mL acetonitrile was added dropwise at 10-15 °C for 45 min.
- The solution was stirred for 3 h at 25 °C.
- The precipitate was collected by suction filtration and suspended in 300 mL of water with magnetic stirring for 3 h.
- The precipitate was washed and dried in a vacuum at 80 °C for 8 h.

Mono (6-ethylenediamine)- β -CD

- A solution of 6.45 g of mono[6-O-(p-toluenesulfonyl)]- β -CD in 22.5 g of ethylenediamine was stirred at 70 °C for 24 h.
- The solution was poured into 400 mL of ethanol.
- The precipitate was collected by suction filtration and dried in vacuum at 80 °C for 8 h.
- The powder was recrystallized two times in 10 mL of water and dried in a vacuum at 80 °C for 8 h.

Silica gel-grafted (3-chloropropyl)trimethoxysilane

- 40 g of silica gel was added to a solution of 100 mL of 37% hydrochloric acid in 100 mL of water.
- The mixture was heated and stirred for 12 h.
- The activated silica gel was collected by suction filtration, washed with distilled water and dried in a vacuum at 150 °C for 12 h.
- 30 g of silica gel was suspended in a solution of 30 mL of anhydrous triethylamine, 50 mL of (3-chloropropyl)trimethoxysilane and 250 mL of dry toluene.
- The mixture was heated and stirred for 72 h under nitrogen atmosphere.
- The suspension was filtered, washed, and dried in a vacuum at 80 °C for 24 h.

Silica gel-grafted β -CD

[44]

Magnetic
molecularly
imprinted polymer
methacrylic acid- β -
CD

- 20 g of silica gel-grafted was added to a solution of 20 g of mono (6-ethylenediamine)- β -CD, 0.5 g of potassium iodide in 250 mL of N, N-dimethylformamide.
- The mixture was heated and stirred at 110 °C for 96 h under nitrogen atmosphere.
- The suspension was filtered, washed, and dried in a vacuum at 80 °C.

Methacrylic acid- β -cyclodextrin monomer

- 0.5 M methacrylic acid and 1 M toluene 2,4-diisocyanate were mixed in 40 mL dimethylacetamide solvent.
- 0.1 % dibutyltin dilaurate was added and the solution was stirred magnetically in an inert atmosphere for 1 h at 25 °C.
- 0.5 M β -CD and 10 mL dimethylacetamide were added and stirred for 2 h.

Magnetic molecularly imprinted polymer methacrylic acid- β -CD

- 0.56 mmol methacrylic acid- β -cyclodextrin monomer, 2.80 mmol trimethylolpropane trimethacrylate and 1 g Benzoyl peroxide were added.
- The mixture was purged for 10 min with nitrogen gas, sealed and allowed to polymerize for 24 h in a water bath at 70 °C.
- The product was crushed, grounded and sieved to obtain regular-sized polymer particles.
- The magnetic molecularly imprinted polymer was synthesized via a one-step coprecipitation method under a nitrogen atmosphere.
- The ratio of magnetic molecularly imprinted polymer: $\text{FeCl}_2 \cdot 4\text{H}_2\text{O} : 2\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ was weighed and mixed in 100 mL of deionized water.
- The mixture was stirred for 30 min at 1200 rpm.
- 12 mL of ammonia solution was added and the mixture was stirred for 1 h at 90 °C.
- The magnetic particles were washed with ethanol and ultrapure water to remove unreacted particles.
- The product was isolated with the application of an external magnet and dried in an oven at 60 °C.
- The polymer was washed with the methanol/ acetic acid (9: 1 v/v) solution and

[46]

Composite/nanocomposite β-CD-based adsorbent	β-CD/chitosan functionalized graphene oxide hydrogel	<p>ultrapure water.</p> <p><i>Graphene oxide</i></p> <ul style="list-style-type: none"> • A mixture of concentrated sulphuric acid/phosphoric acid (360: 40 mL) was slowly added to a mixture of 3 g of graphite flakes and 18 g of potassium permanganate. • The solution was heated to 35-40 °C. • The solution was placed in a water bath at 50 °C and stirred for 12 h. • The mixture was cooled and poured onto 400 mL of ice. • 6-7 mL of 30 % hydrogen peroxide was dropwise added into the mixture and stirred constantly until bright yellow product appeared. • The graphene oxide was washed and freeze-dried. <p><i>β-CD/chitosan functionalized graphene oxide hydrogel</i></p> <ul style="list-style-type: none"> • Graphene oxide was dispersed in deionized water and sonicated for 2 h. • 0.24 g of β-CD was added to 20 mL of graphene oxide solution under magnetic stirring and further sonicated for 30 min. • 0.4 mL of glacial acetic acid and 0.12 g of chitosan were added to the solution and stirred for 2 h. • 1 wt % genipin alcohol solution and 0.2 g of sodium ascorbate were added to the solution and stirred for 10 min. • The solution was transferred into a 100 mL Teflon-lined autoclave and heated at 90 °C for 12 h. • The sample was placed in deionized water for 24 h and the water was changed every 2 h. • The hydrogel was freeze-dried for 24 h. 	[16]
	Graphene oxide-β-CD nanocomposite	<p><i>Graphene oxide</i></p> <ul style="list-style-type: none"> • Phosphoric acid was added dropwise to sulphuric acid and the mixture was stirred at 25-35 °C. • Graphite was added to the mixture. • The black dispersed solution was treated with potassium permanganate and left for 3 d. • Hydrogen peroxide was added dropwise, and yellow coloured solution was 	

formed.

- The pH solution was adjusted to neutral by treating with hydrochloric acid and distilled water.
- The solution was dried in an oven at 70 °C.

Graphene oxide-β-CD nanocomposite

- A solution of 60 mL of graphene oxide in water and 60 mL of mM β-CD were treated with 1 mL of 25-28 % ammonia solution.
- 0.5 mL of 50 % hydrazine solution was added and stirred continuously.
- The vial was heated in a water bath at 60 °C for 8 h.
- The dispersion was filtered by cellulose acetate membrane, washed, and dried in an oven.

Crosslinked
chitosan/β-CD
composite

- 9 g of β-CD and 15 g of maleic anhydride were added in 100 mL of anhydrous N,N-dimethylformamide, and transferred into a two-necked round-bottomed flask under nitrogen atmosphere.
- The mixture was stirred at 25 °C for 48 h.
- 50 mL of ethyl acetate was added to the solution to form white gel-like precipitate and this process was repeated three times.
- The product was recovered by filtration and dried at 50 °C in a vacuum for overnight.
- 2 g of product, 0.5 g of chitosan, and 0.25 g of 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride were dissolved in 100 mL of deionized water.
- The mixture was stirred for 2 h and 0.5 g N-hydroxysuccinimide was added.
- The solution was stirred for 48 h and precipitated with acetone for several times.
- The product was sealed with Parafilm at 4 °C for 12 h and dissolved in 50 mL of 1 % glutaraldehyde solution.

[11]

Graphene/β-CD
composite

- The solution was stirred for 24 h, centrifuged and dried at 60 °C.
- Graphene oxide dispersion was obtained by dissolving the graphene oxide in water.
- The solution pH was adjusted to 9-10 using hydrochloric acid and sodium hydroxide solutions.

[7]

- 12 mL of epichlorohydrin was slowly added into the solution and stirred at 60 °C for 8 h.
 - The produced graphene oxide-O was centrifuged and washed with distilled water.
 - 50 mL of water was added to graphene oxide-O suspension to obtain graphene oxide-O dispersion.
 - 1 g of β -CD was added into the dispersion.
 - 5 mL of hydrazine was slowly added under stirring.
 - The graphene/ β -CD solution was filtered and rinsed with deionized water.
 - Graphene/ β -CD composite was obtained and dried at 60 °C for 48 h.
- β -CD/poly(acrylic acid)/ graphene oxide nanocomposites

Graphene oxide

- 23 mL of sulphuric acid was mixed with 1 g graphite and the mixture was kept at 0 °C in an ice bath.
- 0.5 g of sodium nitrate was added to the mixture, potassium permanganate was gradually added, and the temperature was kept below 10 °C.
- The mixture was stirred with a mechanical stirring for 2 h.
- The mixture was heated to 35 °C for 12 h.
- 140 mL of deionized water was added to the mixture and stirred for 30 min at 90 °C.
- 50 mL of 30 % hydrogen peroxide was added to the mixture and cooled to room temperature.
- The mixture was filtered, washed three times, and dried in a vacuum oven.

(p-tolysulfonyl)- β -CD

- 10 g of β -CD was suspended in 140 mL water and 40 mL of 2.5M sodium hydroxide was added dropwise.
- 2.6 g of p-Toluenesulfonyl chloride in 10 mL of acetonitrile was added to the solution.
- The mixture was agitated for 3 h, filtered, and neutralized with hydrochloric acid.
- The filtrate was kept overnight at 4 °C.
- The precipitate was recovered by filtration and washed 3 times.

[47]

- The crude product was recrystallized from 150 mL of hot water at 90 °C at least three times.
- The pure (p-tolylsulfonyl)- β -CD crystals were dried at 60 °C for 48 h in a vacuum.

NH₂- β -CD (amino-functionalized β -CD)

- 5 g of pure (p-tolylsulfonyl)- β -CD was dissolved in 30 mL of anhydrous ethylenediamine and the mixture was kept at 80 °C for 72 h.
- The solution was cooled to room temperature.
- The crude NH₂- β -CD was obtained re-precipitation of the solution from a large amount of acetone.
- The precipitate was dissolved in a 90 mL of water and 30 mL of methanol.
- The precipitation and dissolution were repeated two more times and the product was dried at 60 °C for 48 h.

β -CD/ poly(acrylic acid)

- 0.5 g of poly(acrylic acid) was dissolved in 45 mL of deionized water, and 1-ethyl-3-(3-dimethylaminopropyl)-carbodiimide hydrochloride and N-hydroxysuccinimide were added to the solution with vigorous stirring.
- The mixture was kept at 0 °C for 10 min.
- 3.5 g of NH₂- β -CD was added to the solution and stirred for 48 h.
- The solution was dialyzed against deionized water for 3 d.
- The solution was concentrated in a rotary evaporator (10-15 wt %) and dried in a vacuum.

β -CD/poly(acrylic acid)/graphene oxide nanocomposites

- 0.1 g of graphene oxide was dispersed in 5 mL of phosphate buffer solution, stirred, and ultrasonicated for 30 min.
- 0.1 g of β -CD/ poly(acrylic acid) and 0.03 g of 1-ethyl-3-(3-dimethylaminopropyl)-carbodiimide hydrochloride were added to the graphene oxide dispersion and the mixture was sonicated at 4 °C for 1 h.
- The mixture was stirred for 48 h at room temperature, centrifuged at 8000 rpm for 10 min, and the solid was washed with deionized water.
- The product was dried for 48 h in a vacuum.

Nanosilica-supported poly β -CD

Silica nanoparticles

[48]

- 18 mL of 28 wt % ammonia solution was mixed with 180 mL of absolute ethanol in a 250 mL single-neck flask.
- 10 mL ethyl orthosilicate was dropwise added into the solution and stirred at 40 °C for 8 h.
- 3-(trimethoxysilyl)propyl methacrylate was added into the solution and reacted with silica nanoparticles for 24 h.
- Solid product (SiO₂-3-(trimethoxysilyl)propyl methacrylate) was recovered by centrifugation, washed, and dried at 60 °C in a vacuum oven.

Modified β -CD

- 8 g of β -CD and 4.38 g of triethylamine were dissolved in 50 mL of N, N-dimethylformamide and stirred at 40 °C.
- The solution was cooled and a solution of 1.36 g of acryloyl chloride in 5 mL of N, N-dimethylformamide was dropwise added into the solution in a period of 30 min.
- Trimethylamine hydrochloride was filtered and poured into a large amount of acetone.
- The product was purified by recrystallizing for three times and dried under vacuum.

Nanosilica-supported poly β -CD

- 0.2 g of β -CD was dissolved in 100 mL mixed solution of deionized water and acetonitrile (v/v, 2:3).
- 0.1 g of SiO₂-3-(trimethoxysilyl)propyl methacrylate was dispersed under ultrasonic dispersion.
- 2,2'-azobis(isobutyronitrile), ethylene glycol dimethacrylate and methylacrylic acid were added into the solution.
- The mixture was heated to boiling state and refluxed for 2 h.
- The product was filtered and washed.
- TiO₂ nanoparticles were heated for 4 h at 300 °C.
- 15 wt % glycine was dissolved in 20 mL methanol at 40 °C.
- 0.1 g of TiO₂ nanoparticles was added into the solution and stirred at 25 °C for

β -CD-glycine-modified TiO₂ nanoparticles

[8]

		<ul style="list-style-type: none"> 24 h. • The mixture was ultrasonicated for 30 min. • The suspension was filtered, washed and dried for 24 h at 60 °C. • 0.4 % (m/v) β-CD was dissolved in 5 mL of deionized water. • 0.5 g of TiO₂/gly was added in the solution and homogenized with a magnetic stirrer. • 2 μL of epichlorohydrin was added to the solution and incubated for 24 h. • The sample was centrifuged and washed with deionized water. 	
	β -CD/citric acid/ polydopamine composite	<p><i>Preparation of citric acid/β-CD</i></p> <ul style="list-style-type: none"> • 0.5 g of monopotassium phosphate, 1.5 g of β-CD, citric acid and 60 mL of deionized water were mixed and stirred/sonicated to homogeneity. • The mixture was heated to 145 °C for 3.5 h. • The product was washed and dried. <p><i>Preparation of β-CD/citric acid/polydopamine composite</i></p> <ul style="list-style-type: none"> • 2 g of citric acid/β-CD was dispersed in 50 mM Tris buffer solution (pH = 8.0–8.5) by magnetic stirring. • 0.4 g of dopamine hydrochloride was added, coating at 25 °C for 24 h. • The sample was washed, centrifuged, and dried. 	[49]
Magnetic β - CD-based adsorbents	Magnetic β -CD stabilized Fe ₃ S ₄ nanoparticles	<ul style="list-style-type: none"> • 1.2 mmol of ferric acetylacetonate, 50 mL of ethylene glycol, and the certain amount of β-CD were mixed under magnetic stirring. • The mixture was heated to 160 °C for 30 min. • 10 mL of 0.012 g/mL thiacetamide ethylene glycol solution was injected continuously to the solution by a syringe pump at 160 °C for 30 min. • The solution was stirred at 160 °C for 2 h (the whole procedure was carried out under nitrogen atmosphere). • The mixture was washed several times, and dried in a vacuum at 60 °C for overnight. 	[63]
	β -CD-chitosan modified Fe ₃ O ₄ nanoparticles	<ul style="list-style-type: none"> • 5 g of 4 % chitosan gel, 1.5 g of maleoyl-β-CD, 0.3 g of 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride and 15 mg of 4-Dimethylaminopyridine were dissolved in 50 mL of water and stirred for 48 h. 	[14]

- The solution was precipitated with 100 mL of acetone and the white precipitate was filtered through a Buchner funnel.
- The precipitate was washed and β -CD-chitosan were obtained.
- 0.3 g of β -CD-chitosan was dissolved in 50 mL of 2 % acetic solution.
- 0.1 g of magnetic particles were added in the solution.
- After ultrasonic dispersion, 3.3 mL of liquid paraffin and Span-80 were added in the solution.
- The solution pH (8-9) was adjusted by adding 1.5% (v/v) ammonium hydroxide solution.
- The solution was mixed with pure glutaraldehyde and stirred at 55 °C for 1.5 h.
- The precipitate was washed and dried in a vacuum oven at 40 °C.

Magnetic β -CD/
graphene oxide
nanocomposite

Graphene oxide nanosheets

- Natural flake graphite was added to concentrated sulphuric acid, nitric acid, and potassium permanganate.
- The mixture was ultrasonicated.
- 20 % hydrogen peroxide was added to the suspension.
- The product was rinsed with deionized water.

Magnetic β -CD/graphene oxide nanocomposite

- 0.5 g of Fe_3O_4 was mixed with 20 mL of 80 mg/mL NH_2 - β -CD and 100 mL of ammonia solution.
- 5.0 mL of pure glutaraldehyde was added to the solution and stirred at 50 °C for 30 min.
- 20 mL of homogenous graphene oxide was added and vigorously shaken for a few minutes, and then was put in a water bath at 60 °C for 3.5 h.
- Magnetic β -CD/ graphene oxide nanocomposite was collected using an adsorbent magnet and was dried in a vacuum oven at 50 °C.

Magnetic β -CD-
chitosan/graphene
oxide

β -CD-chitosan modified Fe_3O_4 nanoparticles

- The 250 mL of 1.5 mol/L ammonia solution was added in a four-neck round-bottomed flask.
- 1.73 g of $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ and 0.627 g of $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ were dissolved in 25 mL of distilled water and N_2 purge gas was connected to the flask.

[9]

[10]

- The solution was dropwise to ammonia solution and stirred in a water bath at 90 °C for 1.5 h.
- Magnetic particles were then obtained by magnetic separation.
- 0.3 g of β -CD-chitosan was dissolved in 50 mL of 3 % acetic solution.
- 0.1 g of magnetic particles were added in the solution.
- After ultrasonic dispersion, the solution pH (8-9) was adjusted by adding 1.5% (v/v) ammonium hydroxide solution.
- The solution was mixed with pure glutaraldehyde and stirred at 55 °C for 1.5 h.
- The precipitate was washed and dried in a vacuum oven at 40 °C.

Magnetic β -CD-chitosan/graphene oxide

- A graphene oxide was sonicated for 2 h in ultrapure water.
- 0.1 M 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride and 0.1 M N-hydroxyl succinimide were added to the graphene oxide dispersion with continuous stirring for 2 h.
- The solution pH was maintained at 7 using dilute sodium hydroxide.
- 0.1 g of magnetic β -CD-chitosan, the activated graphene oxide solution and 5 mL glutaraldehyde were mixed and dispersed by ultrasonic dispersion for 10 min.
- The solution was stirred at 65°C for 2 h.
- The precipitate was washed, collected by magnet and dried in vacuum oven at 50 °C.

Carboxymethyl- β -
CD modified Fe₃O₄
nanoparticles

Carboxymethyl- β -CD

- A mixture of 10 g of β -CD and 9.3 g of sodium hydroxide was mixed in 37 mL water.
- The solution was treated with a 27 mL of 16.3 % monochloroacetic acid solution at 50 °C for 5 h.
- The solution pH was adjusted to 6-7 using hydrochloric acid.
- The mixture was then poured to superfluous methanol solvent.
- The solid precipitates was filtered and dried in a vacuum.

Carboxymethyl- β -CD modified Fe₃O₄ nanoparticles

- 100 mg of magnetic nanoparticles were added to 2 mL of buffer A and sonicated

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- for 5 min.
- 0.5 mL of carbodiimide solution was added into the mixture and further sonicated for 15 min.
 - 2.5 mL of carboxymethyl-β-CD was added and sonicated for another 90 min.
 - The carboxymethyl-β-CD bound magnetic nanoparticles were recovered using a permanent magnet, washed with buffer A and dried in a vacuum oven.
- Carboxymethyl-β-CD conjugated magnetic nanoparticles *Carboxymethyl-β-CD* [53]
- A mixture of β-CD and sodium hydroxide in water was treated with a 16.3% monochloroacetic acid solution at 50 °C for 5 h.
 - The mixture pH was adjusted to 6-7 using hydrochloric acid.
 - The mixture was then poured to superfluous methanol solvent.
 - The precipitated solid was filtered and dried to produce carboxymethyl-β-CD.
- Carboxymethyl-β-CD modified Fe₃O₄ nanoparticles*
- i) Carbodiimide (two-steps method):*
- 100 mg of magnetic nanoparticles were added to 2 mL of buffer A and sonicated for 5 min.
 - 0.5 mL of carbodiimide solution was added into the mixture and further sonicated for 15 min.
 - 2.5 mL of carboxymethyl-β-CD was added and sonicated for another 90 min.
 - The carboxymethyl-β-CD bound magnetic nanoparticles were recovered using a permanent magnet, washed with buffer A and dried in a vacuum oven.
- ii) Co-precipitation (one-step method):*
- 1 g of Fe₃O₄ precipitate and 1.5 g of carboxymethyl-β-CD were dissolved in 400 mL of de-aerated Milli-Q water with vigorous stirring.
 - 5 mL of 25% NH₄OH was added into the solution and was heated for 1 h at 90°C under constant stirring and nitrogen environment.
 - The resulted nanoparticles were washed and dried in a vacuum oven.
- Carboxymethyl-β-CD modified Fe₃O₄ nanoparticles *Carboxymethyl-β-CD* [6]
- 5 g of β-CD was dissolved in 50 mL of 10 % sodium hydroxide.
 - 10 mL of epichlorohydrin was added into the solution and stirred for 8 h.
 - Another 5 mL of epichlorohydrin was added and the mixture was kept for 24 h

at 24 °C.

- The solution was precipitated by addition of 500 mL of cold ethanol.
- The precipitate was crushed several times with ethanol in a mortar to obtain fine precipitate.
- The precipitate was washed and dried under high vacuum for 12 h.
- 2 g of the above polymer was dissolved in 50 mL of 5 % sodium hydroxide and 2 g of monochloroacetic acid.
- The mixture was stirred for 24 h, neutralized with 2 M hydrochloric acid, concentrated to 15 mL and cooled to 4 °C.
- The precipitate was filtered and the supernatant was precipitated by addition of 500 mL cold ethanol.
- The precipitate was washed and dried under high vacuum for 12 h.

Carboxymethyl-β-CD coated Fe₃O₄ nanoparticles

- 0.86 g of FeCl₂·4H₂O, 2.36 g of FeCl₃·6H₂O and 1.5 g of carboxymethyl-β-CD were dissolved in 40 mL of de-aerated Milli-Q water with stirring at 1200 rpm and heated up to 90 °C.
- 5 mL of 25 % NH₄OH was mixed into the solution at 90 °C for 1 h under nitrogen environment.
- The carboxymethyl-β-CD coated Fe₃O₄ nanoparticles were washed and dried in a vacuum oven.

Amino Fe₃O₄ nanoparticles

- 1.35 g of ferric chloride hexahydrate, 1 g of polyethylene glycol, 3.6 g of anhydrous sodium acetate, and 40 mL of ethylene glycol solution were mixed and stirred for 30 min.
- The mixture was transferred into a stainless steel autoclave, and maintained at 200 °C for 8 h.
- The precipitate was obtained by magnetic separation, washed, and dried at 40 °C for 6 h.
- The Fe₃O₄ nanoparticles were obtained.
- 0.1 g of Fe₃O₄ nanoparticles and 200 mL of 99.5 % ethanol were mixed with a mechanical agitation for 30 min.

Magnetic β-CD-graphene oxide nanocomposites

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- 2 mL of 3-aminopropyltriethoxysilane was added to the solution and stirred for 6 h.
- The precipitate was washed, dried in a vacuum at 40 °C for 6 h.

Graphene oxide

- 120 mL of sulphuric acid, 13 mL of phosphoric acid, 6 g of potassium permanganate, and 1 g of graphite flakes were mixed.
- The mixture was heated and stirred at 50 °C for 12 h.
- The mixture was poured into a solution of 130 mL of ice and 3 mL of 30 % hydrogen peroxide.
- The mixture was centrifuged at 8000 rpm for 1 h, and the supernatant was decanted away.
- The solid was washed, and dried in a vacuum at 40 °C for 6 h.

Carboxymethyl-β-CD

- 2 g of β-CD, 1.86 g of sodium hydroxide, and 1.06 g of monochloroacetic were dissolved in 12.8 mL of water, and ultrasonicated for 30 min.
- The mixture was heated to 50 °C for 5 h with magnetic stirring.
- The solution was cooled, and neutralized (6-7) by adding hydrochloric acid.
- The solution was poured to superfluous methanol solvent.
- The precipitate was dried in a vacuum at 40 °C for 6 h.

β-CD-graphene oxide nanocomposites

- 0.1 g of Fe₃O₄ nanoparticles were mixed with 20 mL of 0.003 M sodium phosphate buffer and ultrasonicated for 30 min.
- 0.1 g of 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride and 0.5 g of carboxymethyl-β-CD were dissolved in 10 mL of sodium phosphate buffer, and added to the solution.
- The mixture was ultrasonicated for 30 min, and stirred for 2 h.
- The product was washed, dried in a vacuum at 40 °C for 6 h.
- 0.1 g of graphene oxide was added into 50 mL of water.
- 0.1 g of 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride and 0.1 M of N-hydroxyl succinimide were added to the graphene oxide dispersion, and stirred for 2 h.

Ammonium β -CD-conjugated magnetic nanoparticles	<ul style="list-style-type: none"> • 0.2 g of $\text{Fe}_3\text{O}_4/\beta$-CD were added to the solution, and dispersed for 30 min. • The product was collected using external magnet, and dried in a vacuum at 40 °C for 6 h. <p><i>Magnetic nanoparticles</i></p> <ul style="list-style-type: none"> • $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ and $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ (molar ratio, 2:1) were reacted under nitrogen atmosphere. • The solution pH was adjusted (10-11) by adding excess ammonia solution under ultrasonic agitation, and was dispersed for 30 min. 	[54]
Magnetic copper-based metal-organic framework	<p><i>Quaternary ammonium β-CD-conjugated magnetic nanoparticles</i></p> <ul style="list-style-type: none"> • 10 g of β-CD and 2.6 g of succinic anhydride were dissolved in N, N-dimethylformamide, and stirred at 70 °C for 10 h under nitrogen atmosphere. • The solution pH was adjusted (8-9) by adding 10 wt % sodium hydroxide solution. • 5.34 g of 2, 3-glycidyltrimethylammonium chloride was added, and stirred at 70 °C for 6 h. • The solution pH was adjusted (5-6) and was kept for 2 h. • 0.681 g of magnetic nanoparticles were added to the solution, ultrasonicated, and kept for 20 min under nitrogen atmosphere. • The precipitate was washed, and dried in a vacuum at 60 °C for 12 h. <p><i>Fe_4O_3-graphene oxide</i></p> <ul style="list-style-type: none"> • 0.2 g of graphene oxide powder was sonicated in 240 mL of ultrapure water for 1 h. • 1.8 g of $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ and 0.8 g of $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ were dissolved in 25 mL of ultrapure water under nitrogen atmosphere. • 240 mL of graphene oxide solution was added to the solution and stirred at 80 °C for 1 h. • 10 mL of 28 wt % ammonium hydroxide added to the solution and stirred for 30 min and kept cooled. • The Fe_4O_3-graphene oxide nanoparticles were recovered by magnetic separation, washed, and dried in a vacuum at 60 °C for 24 h. 	[51]

Fe₄O₃-graphene oxide-β-CD

- 0.1 g of Fe₄O₃-graphene oxide was sonicated in 20 mL of 0.01 M phosphate buffer for 30 min.
- 70 mg of 1-(3-Dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride and 30 mg of N-Hydroxysuccinimide were added to the solution and stirred for 1 h.
- 20 mg of amino-β-CD was dissolved in 10 mL of ultrapure water.
- The solutions were mixed and incubated for 24 h.
- The Fe₄O₃-graphene oxide-β-CD nanoparticles were recovered, washed, and dried in a vacuum at 60 °C for 24 h.

Magnetic copper-based metal-organic framework

- 0.15 g of Fe₄O₃-graphene oxide-β-CD nanoparticles were dispersed in 20 mL of 20 mM mercaptoacetic acid/ethanol solution and shaken for 1 h.
 - The product was separated magnetically and washed.
 - The Fe₄O₃-graphene oxide-β-CD nanoparticles were added to a solution of 120 mL of dimethylformamide/ethanol solution (v/v, 1/1) and 750 mg of 1, 3, 5-Benzenetricarboxylic acid.
 - The mixture was stirred for 3 h.
 - 1290 mg of Cu(CH₃COO)·H₂O was dissolved in 60 mL of ultrapure water and added to the solution.
 - 0.75 mL of triethylamine was added dropwise and stirred for 3 h.
 - The product was separated by magnetic decantation, washed, and dried in a vacuum at 80 °C for 24 h.
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