SYNTHESIS OF THERMO-MAGNETO-RESPONSIVE POLY(*N*-ISOPROPYLACRYLAMIDE)-BASED COMPOSITE HYDROGELS FOR ADSORPTION-DESORPTION OF CHROMIUM (III) IONS

by

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TABLE OF CONTENTS

CHAPTER TWO: LITERATURE REVIEW

CHAPTER THREE: MATERIALS AND METHODS

LIST OF PUBLICATIONS

LIST OF TABLES

Page

LIST OF FIGURES

LIST OF ABBREVIATIONS

AA	Acrylic acid
AAm-CA	Acrylamide-crotonic acid
AAS	Acrylic acid shell
AC	Activated carbon
AEM	Aminoethyl methacrylate hydrochloride
Ag^{+}	Silver (I) cation
APS	Ammonium persulfate
APTES	3-Aminopropyltriethoxysilane
AS-MNPs	Amino modified silica-iron oxide magnetic nanoparticles
Au	Gold
3-bt	3-butenoic acid
$Ca(OH)_2$	Lime (calcium hydroxide)
CCGO	Magnetic cyclodextrin-chitosan / graphene oxide
Cd^{2+}	Cadmium (II) cation
CEC	Cation exchange capacity
C_2H_4CONH	Acrylamide
C_3H_8NH	Pyrrolidine
$C_4H_{10}NH$	Piperidine
CM	Carboxymethylated
CM-β-CD-MNPs	Carboxymethyl-β-cyclodextrin (CM-β-CD) modified Fe_3O_4 nanoparticles
Co^{2+}	Cobalt (II) cation
CO	Carbonyl group
CONH	Amide group
COO^{-}	Carboxylate group
COOH	Carboxylic group
Cr	Chromium
Cr^{3+}	Chromium (III) cation
Cr^{6+}	Chromium (VI) cation
$CrC1_3 \cdot 6H_2O$	Chromium (III) chloride hexahydrate

$CrN_3O_9 \cdot 9H_2O$	Chromium (III) nitrate nonahydrate
$Cr(H_2O)_6^{3+}$	Hexaaquachromium (III) cation
$Cr(OH)^{4-}$	Tetrahydroxochromate (III) anion
$Cr(OH)_3$	Chromium (III) hydroxide
$Cr_2(OH)_2^{4+}$	Binuclear dihydroxochromium (III) cation
$Cr_3(OH)_4^{5+}$	Trinuclear tetrahydroxochromium (III) cation
CS	Chitosan
CS	Core-shell
Cs^+	Cesium (I) cation
CS-PAA	Chitosan-poly(acrylic acid)
CTAB	Cetyltrimethylammonium bromide
Cu^{2+}	Copper (II) cation
DBS	n-dodecylbenzenesulfonic
D_h	Hydrodynamic diameter
DLS	Dynamic light scattering
DNA	Deoxyribonucleic acid
ED	Electrodialysis
EDC·HCl	(3-dimethylaminopropyl) carbodiimide hydrochloride
EtOH	Ethanol
Eu^{3+}	Europium (III) cation
FAU	Faujasites
Fe^{2+}	Ferrous ion
Fe^{3+}	Ferric ion
$Fe(acac)_3$	Ferric acetylacetonate
$Fe_2(CrO_4)_3$	Ferrous chromate
Fe_3O_4	Magnetite
γ-Fe_2O_3	Maghemite
FRP	Free radical polymerization
FT-IR	Fourier transform infrared spectroscopy
GLA	Glutaraldehyde
HAC	High adsorption capacities
HEMA	2-Hydroxyethyl methacrylate

HCl	Hydrochloric acid
HEC-g-PAA	Hydroxylethyl cellulose-g-poly(acrylic acid)
Hg^{2+}	Mercury (II) cation
H_2O	Water
IDA	Iminodiacetic acid
IEP	Isoelectric point
IPN	Inter-penetrating networks
KPS	Potassium persulfate
LCST	Lower critical solution temperature
LOD	Limit of detection
MBA	*N*, *N*'-methylene-bis-acrylamide
MgO	Magnesium Oxide
MC	Merocyanine
MNPs	Iron Oxide Magnetic Nanoparticles
MPS	3-(trimethoxysilyl)propyl methacrylate
MW	Molecular weight
MWCO	Molecular weight cut-off
$NaNO_3$	Sodium nitrate
NaOH	Sodium hydroxide
Na_2SO_4	Sodium sulfate
NF	Nanofiltration
Ni^{2+}	Nickel (II) cation
NIPAM	*N*-isopropylacrylamide
NH	Amine group
NHS	N-hydroxysuccinimide
OH	Hydroxyl group
PAA	Poly(acrylic acid)
PAAm-HAp	Polyacrylamide-hydroxyapatite
PAC / PEG	Polyacrylate / poly(ethylene glycol)
P(AMPS-co-GT)-GO	Poly[(2-acrylamido-2-methyl propanesulfonic acid)-co-gum tragacanth] grafted graphene oxide composite

P(AMPS-co-IA)	Poly[2-(acrylamido)-2-methyl-1-propanesulfonic acid-co-itaconic acid]
Pb^{2+}	Lead (II) cation
PEDOT / PSS	Lignin-poly(3,4-ethylenedioxythiophene) / polystyrene sulfonate
PEGDA	Poly(ethyelene glycol) diacrylate
PNaAA	Poly(sodium acrylate)
PNIPAM	Poly(*N*-isopropylacrylamide)
PNIPAM-co-AA	Poly(*N*-isopropylacrylamide-co-acrylic acid)
(PNIPAM-co-AA)-silica-PVP-MNPs	Poly(*N*-isopropylacrylamide-co-acrylic acid)-gelated silica- poly(vinylpyrrolidone)-iron oxide magnetic nanoparticles composite hydrogel
PNIPAM-co-AAm-co-MA	Poly(*N*-isopropylacrylamide-co-acrylamide-co-maleic acid)
P(NIPAM-co-BCAm)	Poly(*N*-isopropylacrylamide-co-benzo-18-crown-6-acrylamide)
PNIPAM-silica-PVP-MNPs	Poly(*N*-isopropylacrylamide)-gelated silica-poly(vinylpyrrolidone)-iron oxide magnetic nanoparticles composite hydrogel
PSt	Polystyrene
P(St-NIPAM)	Poly(styrene-*N*-isopropylacrylamide)
PSt-PNIPAM	Polystyrene-poly(*N*-isopropylacrylamide)
PVP	Poly(vinylpyrrolidone)
P(4-VP-co-HEMA)	Poly(4-vinyl pyridine-co- 2-hydroxyethylmetacrylate)
SCH_2COOH	Thiodiglycolic acid
SDBS	Sodium n-dodecylbenzenesulfonate
SH	Sodium humate
silica	Silica coating layer
SiOH	Silanol
SiOSi	Siloxane
SO_3H	Sulfonic acid
SP	Spiropyran

SP-PNVCL	Spiropyran-ended poly(N-vinyl caprolactam)
Sr^{2+}	Strontium (II) cation
St	Starch
TEOS	Tetraethyl orthosilicate
Th^{4+}	Thorium (IV) cation
THF	Tetrahydrofuran
TS-SPE	Temperature-swing solid-phase extraction
U^{6+}	Uranium (VI) cation
UF	Ultrafiltration
UO_2^{2+}	Uranyl cation
UV	Ultraviolet
UV-Vis	Ultraviolet-visible
V50	2,2'-Azobis(2-amidinopropane) dihydrochloride
VIM	*n*-vinyl imidazole
VPT	Volume phase transition
VPTT	Volume phase transition temperature
Zn^{2+}	Zinc (II) cation

LIST OF SYMBOLS

T	Temperature (°C and K)
pK_a	Acid dissociation constant
pK_b	Base dissociation constant
D_h	Hydrodynamic diameter (nm)
ζ	Zeta potential (mV)
R	Cr^{3+} removal percentage (%)
C_0	Initial concentration of copper (II) cations in solution (mg L^{-1})
C_e	Equilibrium concentration in solution (mg L^{-1})
M	Dry mass of adsorbent (g)
V	Total volume of solution (L)
q_e	Equilibrium adsorption capacity (mg g^{-1})
q_m	Maximum equilibrium adsorption capacity (mg g^{-1})
q_t	Equilirium adsorption capacity at time t (mg g^{-1})
K_L	Langmuir constant (L mg^{-1})
R_L	Langmuir separation factor
K_F	Freundlich constant (L g^{-1})
$1/n$	Freundlich heterogeneity factor
B	Dubinin-Radushkevich constant related to adsorption energy (mol^2 $k^{-1}J^{-2}$)
R	Gas constant (8.314 J $mol^{\cdot -1}K^{-1}$)
ε	Polanyi potential

E	Free mean energy of the adsorption (kJ mol^{-1})
b	Temkin constant related to heat of adsorption (J mol^{-1})
K_T	Temkin constant (L g^{-1})
θ	Degree of surface coverage by adsorbates
K_{FH}	Flory-Huggins equilibrium constant (L g^{-1})
n	Flory-Huggins model exponent
ΔG^o	Standard free energy change (kJ mol^{-1})
K_{FR}	Frumkin equilibrium constant (L g^{-1})
a	interaction parameter related to the interaction energy of the adsorbates
k_1	Pseudo-first-order rate constant (min^{-1})
k_2	Pseudo-second-order rate constant (g mg^{-1} min^{-1})
k_{id}	Intra-particle diffusion rate constant (mg $g^{-1}min^{-1/2}$)
C_{id}	Constant related to the thickness of the boundary layer (mg g^{-1})