LIST OF SYMBOLS

a	Constant for Langmuir equation ($m^3 kg^{-1}$)
a_R	Redlich-Peterson isotherm constant $(m^3 kg^{-1})^{-1/\beta_R}$
A	Toth isotherm constant
b	Constant for Langmuir equation ($m^3 kg^{-1}$)
B	Toth isotherm constant
B_B	Dubinin–Radushkevich equation parameter ($mol^2 kJ^{-2}$)
C_{ad}	Reduction of adsorbate concentration of solution at equilibrium (kg/m^3)
C_e	Equilibrium concentration of naringin solution (KPBW) (kg/m^3)
C_{ed}	Final concentration of naringin at equilibrium in alcohol solution (kg/m^3)
C_t	Concentration of adsorbate at time t (kg/m^3)
C_{td}	Concentration of naringin in ethanol at time t
$\overline{C_t}$	Concentration of adsorbate in adsorbent at any time t (kg/m^3)
C_o	Initial concentration of naringin in solution (KPBW) (kg/m^3)
C_o^{I}	Concentration of naringin at the start of three distinct zones (kg/m^3)
D	Toth isotherm constant
D_c	Mass diffusivity of adsorbate in macropores $(m^2 s^{-1})$
D_e	Boyd's effective diffusivity for adsorption $(m^2 s^{-1})$
D_{ed}	Boyd's diffusivity for desorption $(m^2 s^{-1})$
D_P	Mass diffusivity of adsorbate in microspheres $(m^2 s^{-1})$
E	Mean free energy of sorption ($kJ\,mol^{-1}$)

F_n $\left[\frac{1}{(1-u_t)^{2/3}}-1\right]$

H_{UNB} Unused bed length (m)

H_T Total bed height (m)

I Adsorption boundary layer thickness

k Volume fraction of adsorbent bead saturated with adsorbate to form the saturated shell before start of three distinct zones

k_f Rate constant of the pseudo-first-order adsorption (s^{-1})

k_s Rate constant for the pseudo-second-order adsorption $(kg\,kg^{-1}s^{-1})$

k_d Intra-particle diffusion rate constant $(kg\,kg^{-1}s^{-1/2})$

k_o Bangham's equation parameter $(m^3\,kg^{-1})$

K Accumulation parameter

$K_{a/d}$ Equilibrium constant between adsorption-desorption at temperature T

K_f Freundlich isotherm constant

K_{fd} Freundlich isotherm constant for desorption

K_R Redlich-Peterson isotherm constant (m^3kg^{-1})

n Freundlich isotherm constant

n_d Freundlich isotherm constant for desorption

q_D Dubinin–Radushkevich isotherm constant (kg/kg)

q_e Amount of naringin adsorbed at equilibrium (kg/kg)

q_{ed} Amount of species desorbed from the resin in ethanol at equilibrium (kg/kg)

q_{ess} Adsorbate adsorbed by the resin in early period kg adsorbate/kg of resin

q_{total}	Total naringin quantity adsorbed in column, (g)
q_s	Saturation loading capacity of the adsorbent bed or equilibrium naringin uptake (kg/kg)
q_t	Amount of naringin adsorbed at at time t (kg/kg)
q_o	Capacity of resin kg adsorbate/kg of resin
q_{od}	Initial naringin content in the resin (kg/kg)
Q	Volumetric flow rate ($m^3 s^{-1}$)
Q_e	Flow rate of eluent
r_c	Radius of microsphere
R	Universal gas constant ($J mol^{-1} K^{-1}$)
R_p	Radius of the spherical adsorbent particle (m)
s	Solid content of resin
t	Time, (seconds)
t_b	Breakthrough time (s)
t_e	Bed exhaustion time (s)
t_t	Time equivalent to total or stoichiometric capacity (s)
t_{total}	Total flow time (s)
t_u	Time equivalent to usable capacity (s)
T	Temperature (K)
u_t	Fractional approach to equilibrium of resin
$u_d(t)$	Fractional attainment of equilibrium at time t in desorption
V	Volume of solution (KPBW) (m^3)

$\overline{V}$	Volume of adsorbent (resin) (m^3)
V_e	Volume of ethanol (m^3)
V_{eff}	The total KPBW volume (m^3)
w	Weight of dry resin (kg)
w_n	Weight of naringin adsorbed on resin (kg)
w_f	Weight of resin without naringin (kg)
W^I	Weight of resin saturated with naringin (kg)
α	Initial adsorption rate
β	$\frac{3\,(1-\varepsilon)q_0}{\varepsilon\, C_0}.\frac{D_c/r_c^2}{D_P/R_P^2}$
β_R	Redlich–Peterson dimensionless parameter
γ	Degree of saturation in the MTZ
ΔG	Gibb's free energy of adsorption ($kJmol^{-1}$)
ΔH	Enthalpy of adsorption ($kJmol^{-1}$)
ΔR	Thickness of initially developed saturated shell
ΔS	Entropy change ($kJmol^{-1}K^{-1}$)
ε	Porosity (voidage) of adsorbent particles
ε_d	Polanyi potential ($kJmol^{-1}$)
ω	Adsorption rate
ρ	Density of swollen particles of adsorbent
ψ	$\frac{3(1-\varepsilon)\ D_c / r_c^2}{\varepsilon\ \ D_P / R_P^2}$
σ	Bangham's equation dimensionless parameter

LIST OF ABBREVIATIONS

AuA	Anhydrogalacturonic acid
Conc:	Concentration
DE	Degree of esterification
GalA	Galacturonic acid
HMP	High methoxyl pectin
KPBW	Kinnow peel boiled water
LMP	Low methoxyl pectin
F.P.D.	Filter paper dried
MC	Methoxy content
MTZ	Mass transfer zone (m)
MW	Molecular weight
O.D.R.	Oven dried resin
T.S.S.	Total soluble solids
^{o}B	Degree brix, equal to % of soluble solids