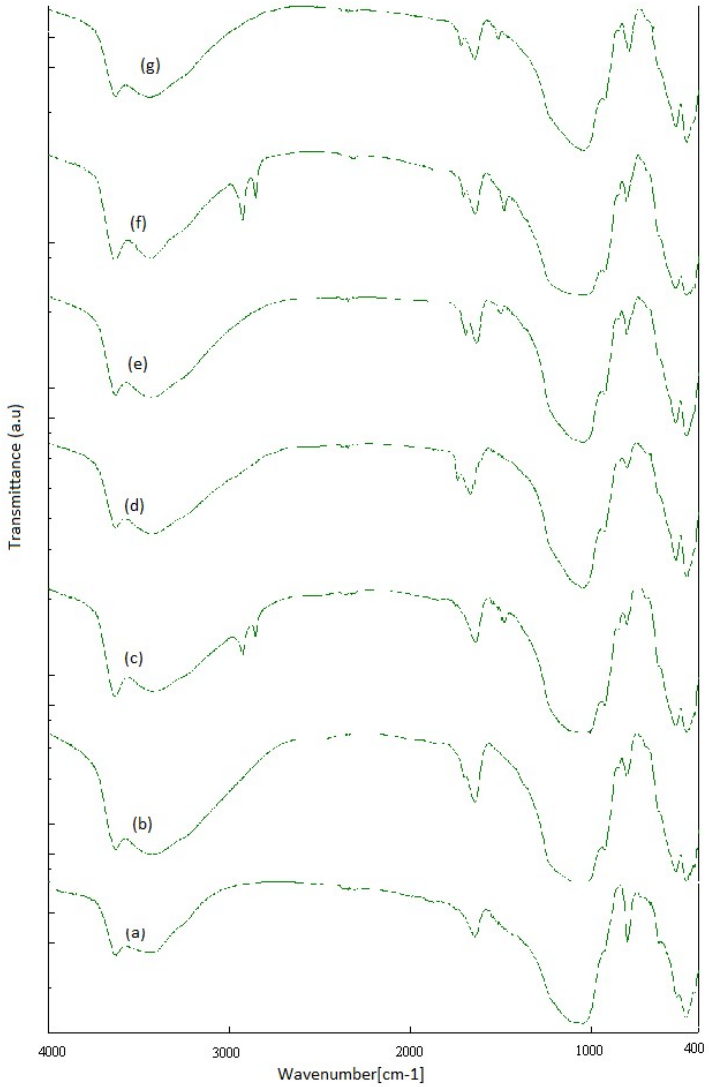
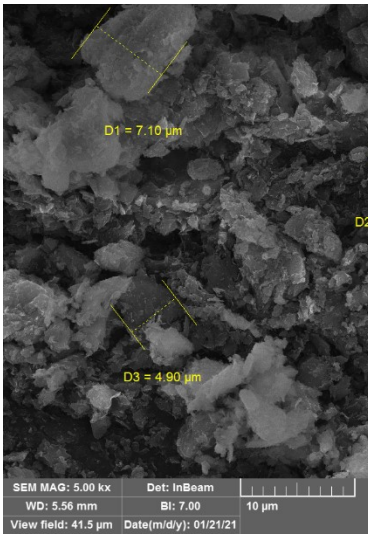
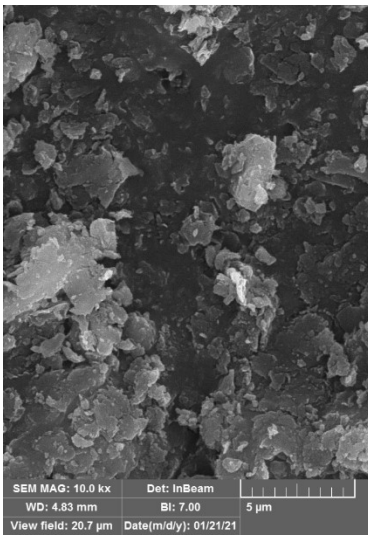


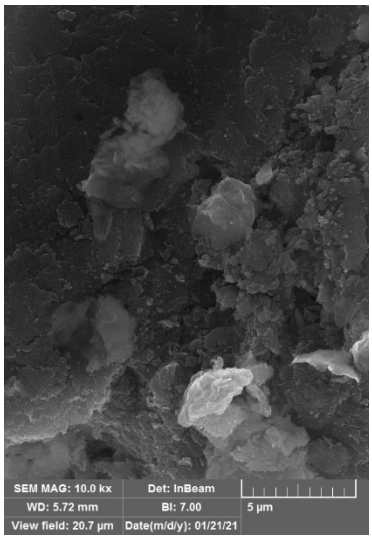
FTIR spectra of (a) Raw bent, (b) ABT-bent, (c) CTAB-bent, (d) GDU-bent, (e) ABT-bent-lac, (f) CTAB-bent-lac, (g) GDU-bent-lac


D1 = 7.10 µm
D3 = 4.90 µm
SEM MAG: 5.00 kx
Det: InBeam
WD: 5.56 mm
BI: 7.00
10 µm
View field: 41.5 µm
Date(m/d/y): 01/21/21

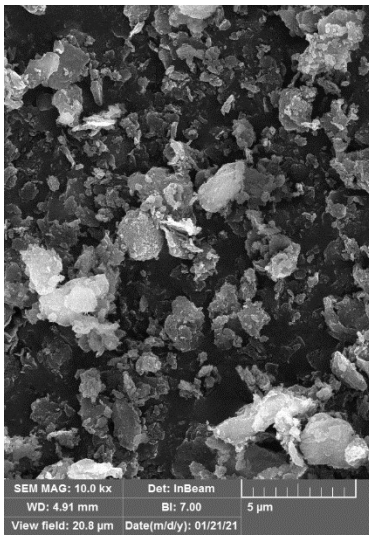
(a)


SEM MAG: 10.0 kx
Det: InBeam
WD: 4.83 mm
BI: 7.00
5 µm
View field: 20.7 µm
Date(m/d/y): 01/21/21

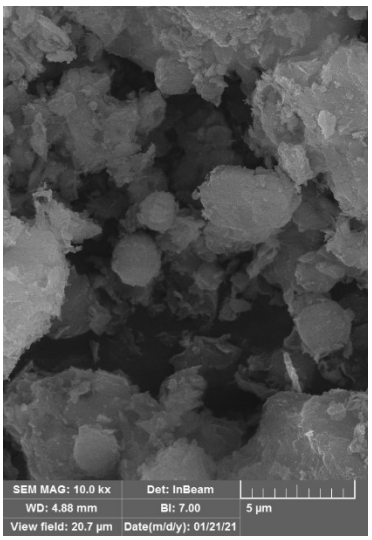
(b)

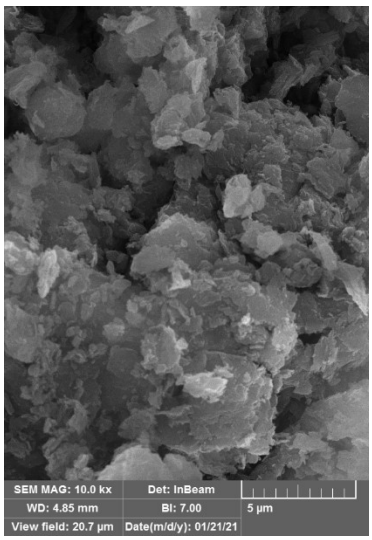

SEM MAG: 10.0 kx
Det: InBeam
WD: 5.72 mm
BI: 7.00
5 µm
View field: 20.7 µm
Date(m/d/y): 01/21/21

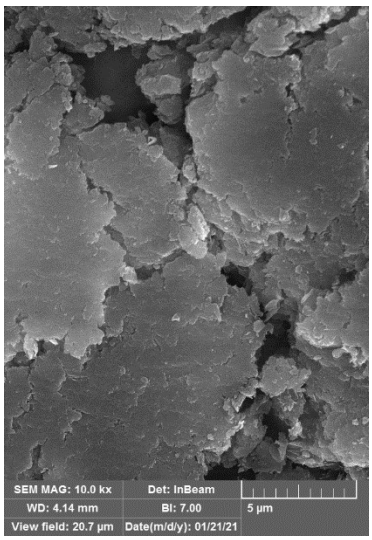
(c)


SEM MAG: 10.0 kx
Det: InBeam
WD: 4.91 mm
BI: 7.00
5 µm
View field: 20.8 µm
Date(m/d/y): 01/21/21

(d)

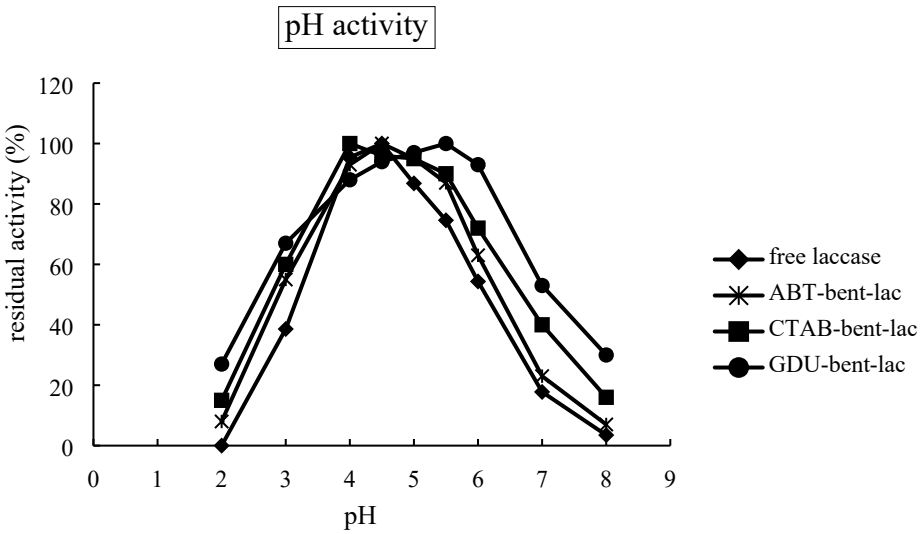

SEM MAG: 10.0 kx
Det: InBeam
WD: 4.88 mm
BI: 7.00
5 µm
View field: 20.7 µm
Date(m/d/y): 01/21/21


SEM MAG: 10.0 kx
Det: InBeam
WD: 4.85 mm
BI: 7.00
5 µm
View field: 20.7 µm
Date(m/d/y): 01/21/21

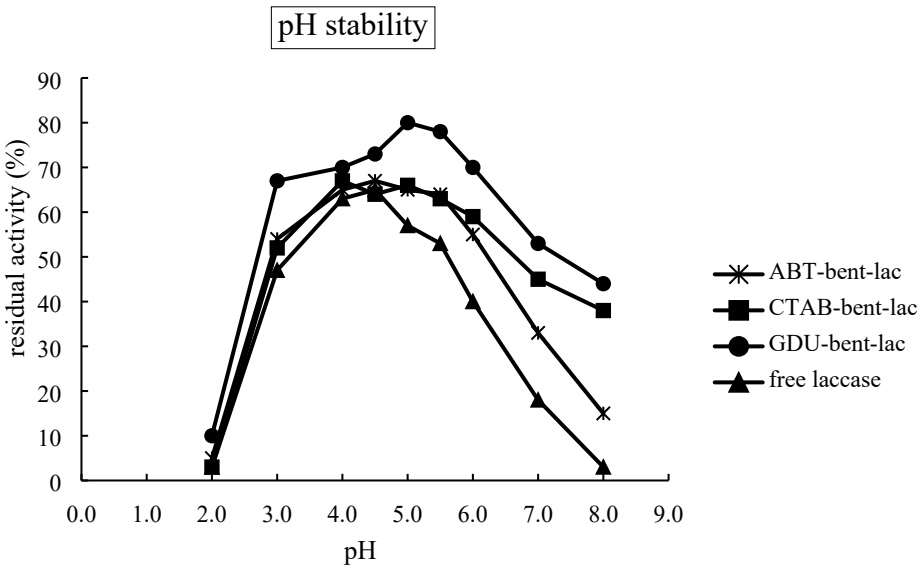

SEM MAG: 10.0 kx
Det: InBeam
WD: 4.14 mm
BI: 7.00
5 µm
View field: 20.7 µm
Date(m/d/y): 01/21/21

(e) (f) (g)

Scanning electron microscopy of a) raw bentonite, b) ABT-bent, c) CTAB-bent, d) GDU-bent, e) ABT-bent-lac, f) CTAB-bent-lac, g) GDU-bent-lac

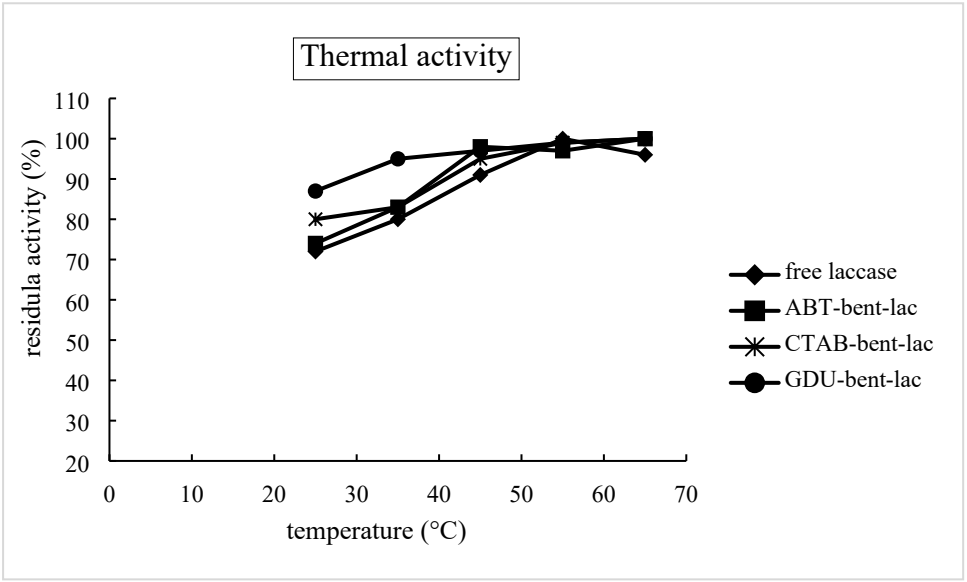


(a)

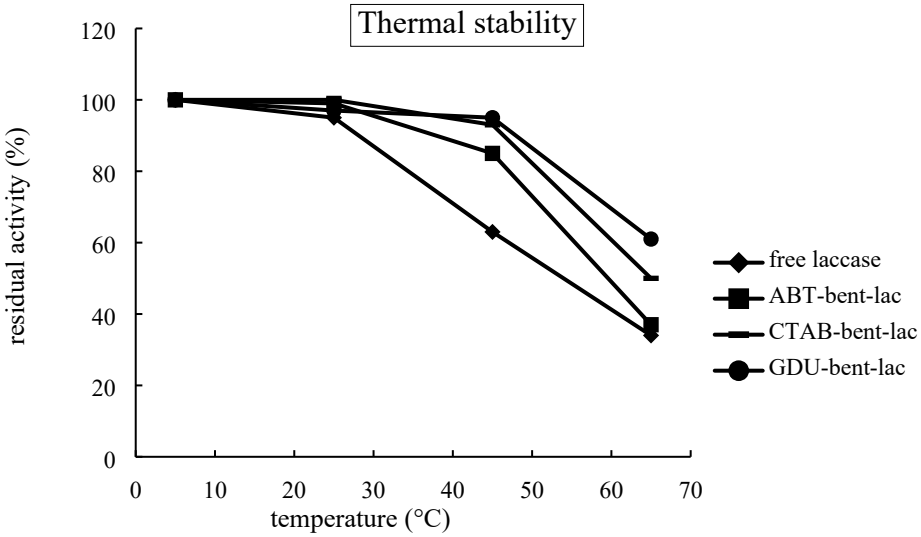


(b)

Effect of pH on: (a) activity and (b) stability of free and immobilized laccase

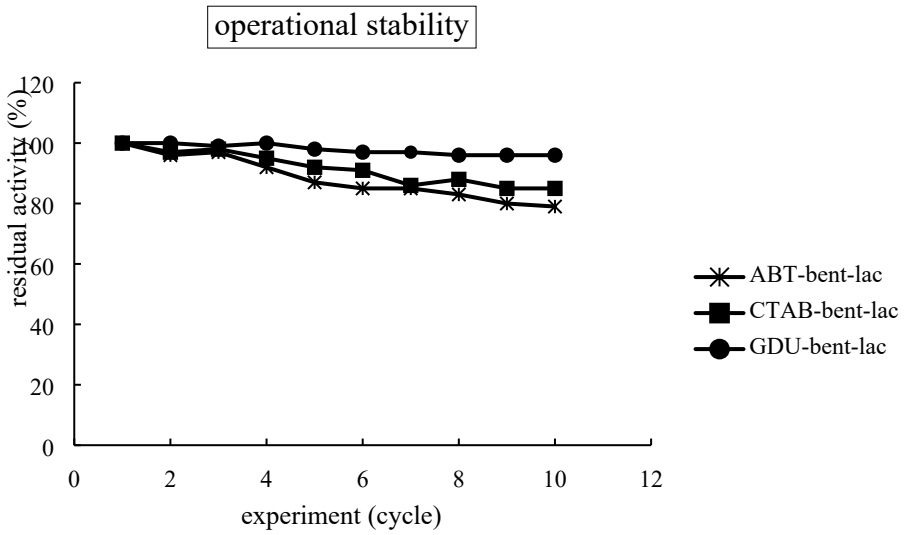


(a)

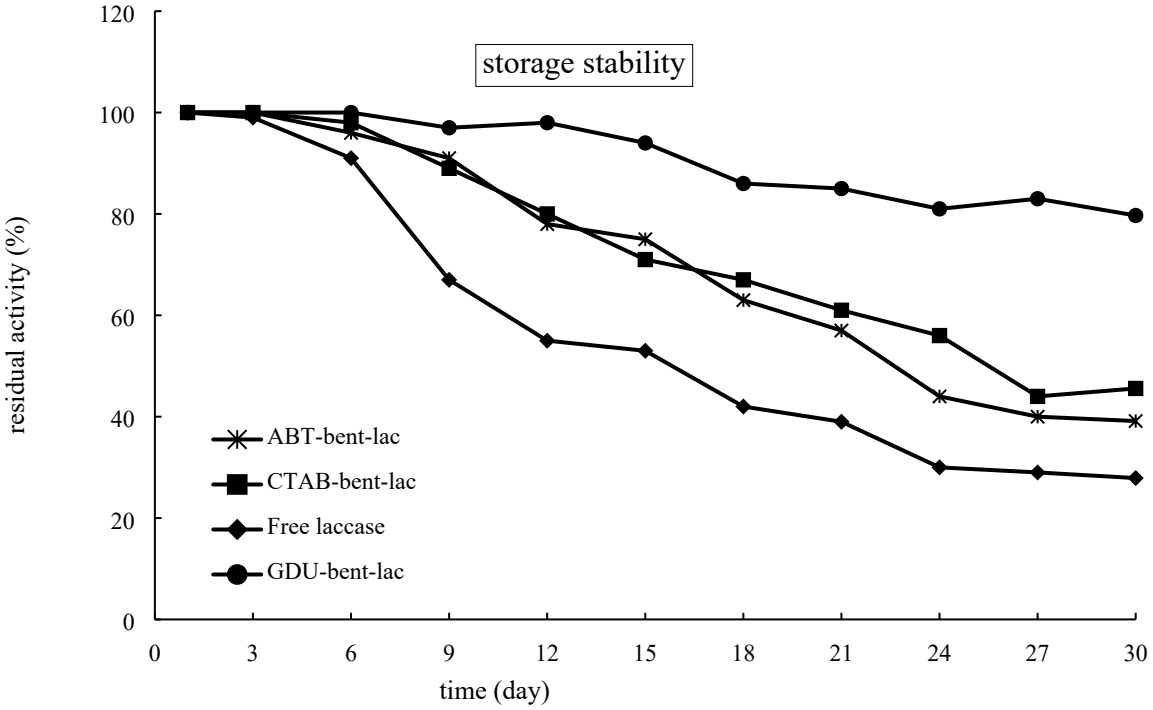


(b)

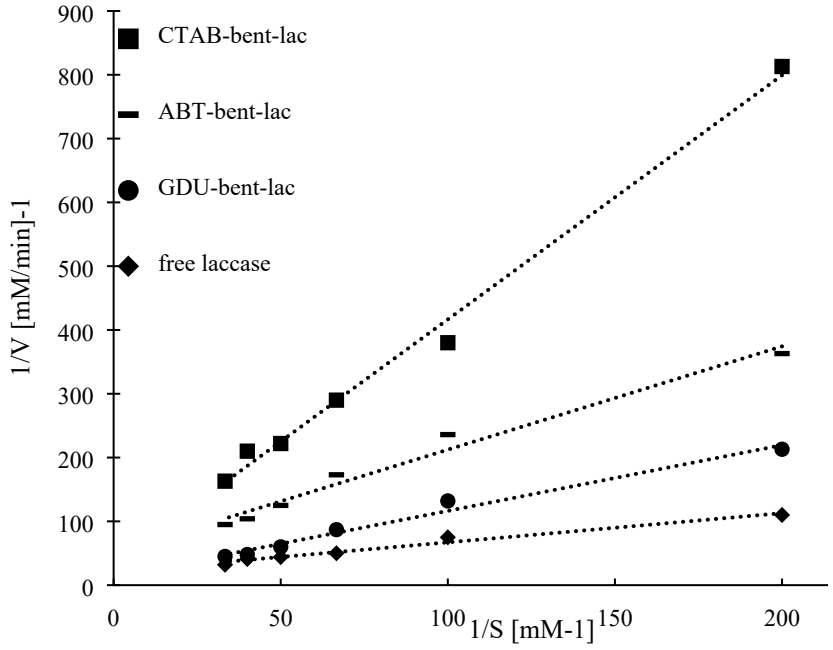
Effect of temperature on: (a) activity and (b) stability of free and immobilized laccase



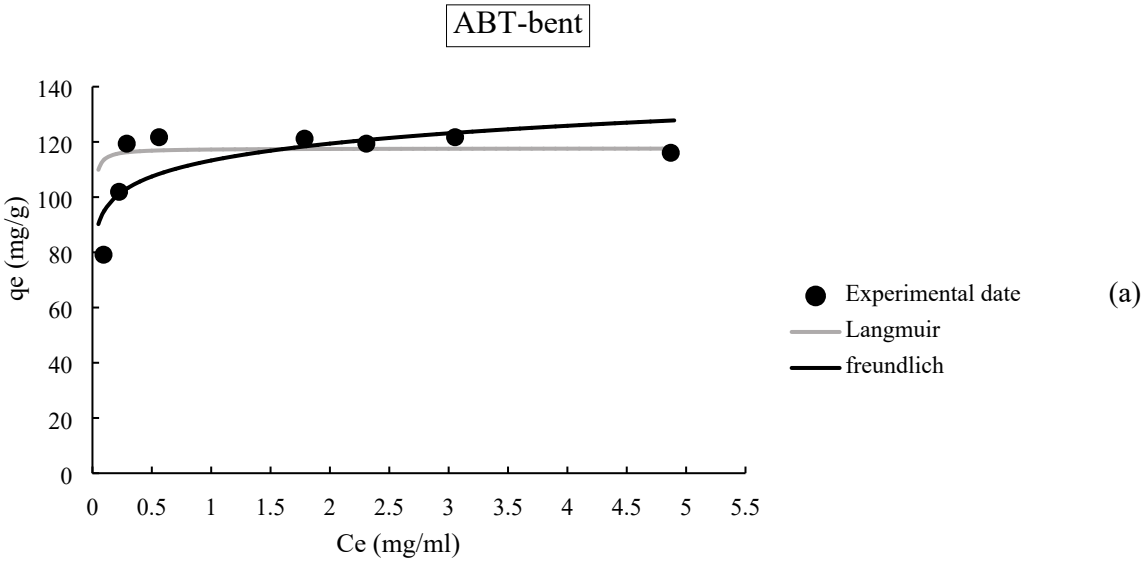
Recycling effect on immobilized laccase activity

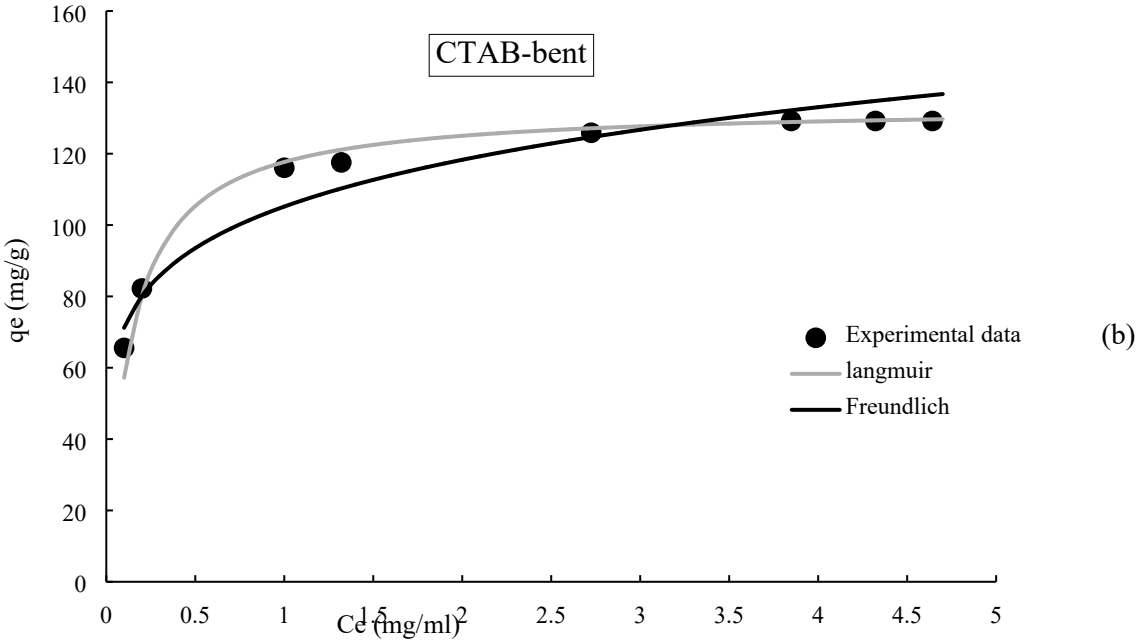


Storage stability of free and immobilized laccase

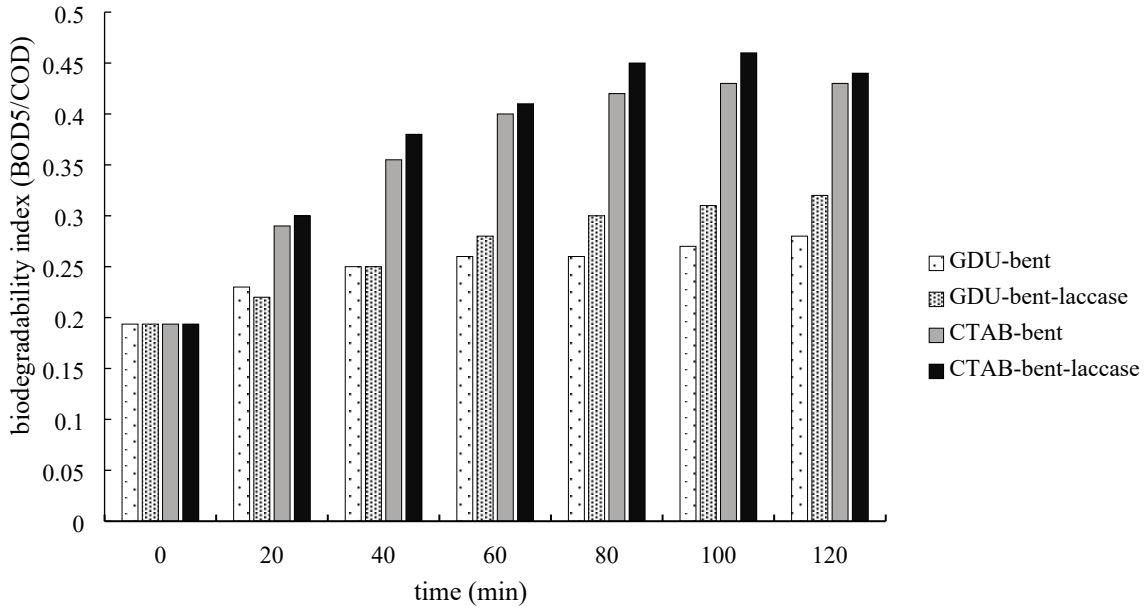


Lineweaver-Burk plot of the free laccase and the immobilized laccase on CTAB-bent, ABT-bent and GDU-bent. Reaction were carried out in pH 4.8 and room temperature.





Adsorption isotherms of proteins onto (a) ABT-bent and (b) CTAB-bent at room temperature



changes in biodegradability index of OMW

Table 1

characteristics of raw OMW used in this study

parameter	Unit	Average value
pH	--	5.05
Water content	(%)	91
Total phenolic content	mg L-1	≈ 1500
Oil and Grease (O & G)	mg L-1	13000
Turbidity		21300
Total Suspended Solid (TSS)	mg L-1	82888
Volatile Organic Compound (VOC)	mg L-1	58021
BOD_5	mg L-1	35000
COD	mg L-1	180720

Table 2characteristics of the raw bentonite

Chemical analysis (%)		Physical analysis		
SiO_2	69.8		Unit	
Al_2O_3	11.88	Water absorption	%	300-700
Fe_2O_3	1.4	Inflation	ml/gr^2	22-25
$Al(OH)_3$	1.07			
CaO	0.96	Humidity	%	4-8
Na_2O	1.03	Montmorillonite	%	86<
MgO	1.42	Grading	Mesh	400
K_2O	0.47	CEC	mEq/100gr	100-110
TiO_2	0.1			

Table 3. Textural characteristics of bentonites and immobilized 1 laccases

Sample	Surface area (m^2/g)	Total pore Volume (C^3/g)	Mean pore diameter (nm)	BJH (nm)
Raw bentonite	32.099	0.0546	6.7989	1.66
ABT-bent	188.6400	0.1745	3.7002	1.22
CTAB-bent	94.1380	0.1186	5.0389	1.22
GDU-bent	201.9000	0.2387	4.7282	1.22
ABT-bent-lac	169.7300	0.1736	4.0918	1.22
CTAB-bent-lac	68.5710	0.1025	5.9784	1.22
GDU-bent-lac	141.5000	0.1484	4.1940	1.22

Table 4 Kinetics values for free and immobilized laccase

	Km (mM)	Vmax (mM.min-1)	Catalytic efficiency (CE)
Free laccase	0.022	0.047	2.184
GDU-bent-lac	0.077	0.075	0.970
CTAB-bent-lac	0.113	0.030	0.261
ABT-bent-lac	0.032	0.020	0.618

Table 5 Parameters of Langmuir and Freundlich isotherms for protein adsorption onto two modified bentonite supports

Models	ABT-bentonite	CTAB-bentonite
	Values	
Langmuir		
q_{max} (mg/g)	117.65	133.33
K_l (L/mg)	0.0035	0.133
R^2	0.9989	0.9998
Freundlich		
K_F (mg/g)	113.26	105.18
n (g/L)	13.17	5.9
R^2	0.5159	0.9413