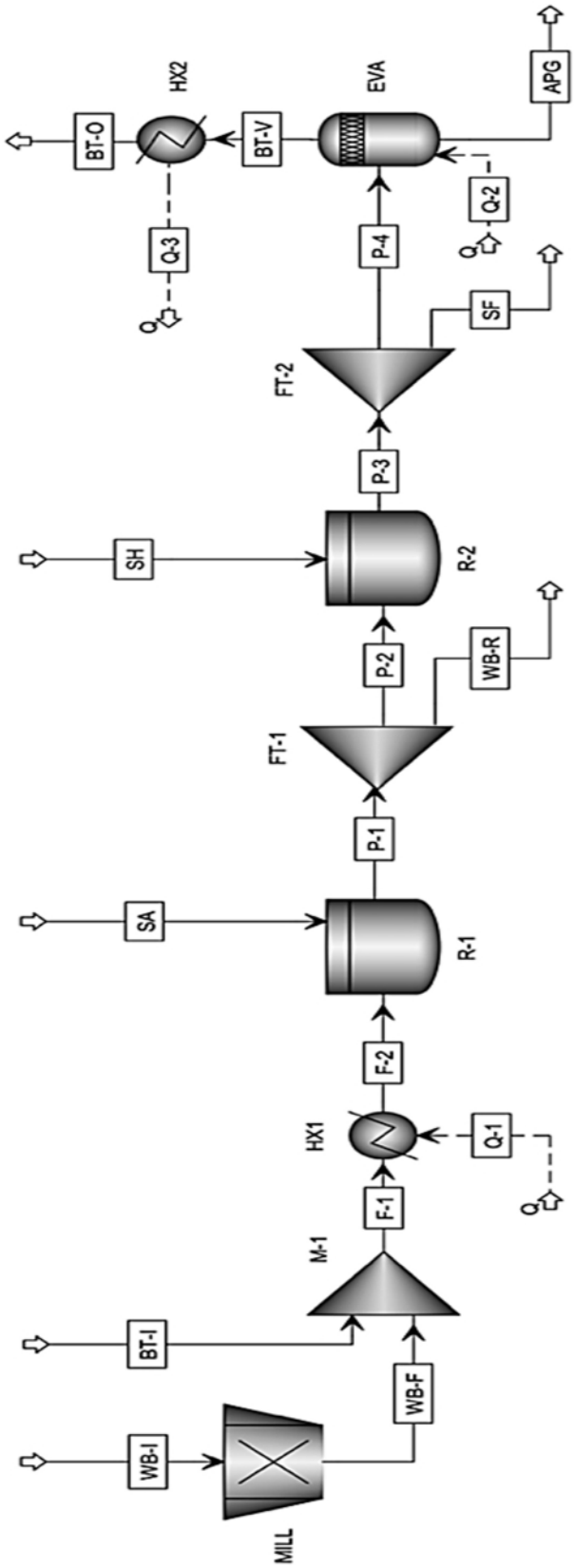

MILL
WB-I
BT-I
M-1
WB-F
F-1
HX1
Q-1
F-2
R-1
SA
P-1
FT-1
P-2
WB-R
R-2
SH
P-3
FT-2
SF
P-4
Q-2
EVA
APG
BT-V
HX2
BT-O
Q-3

Figure 1

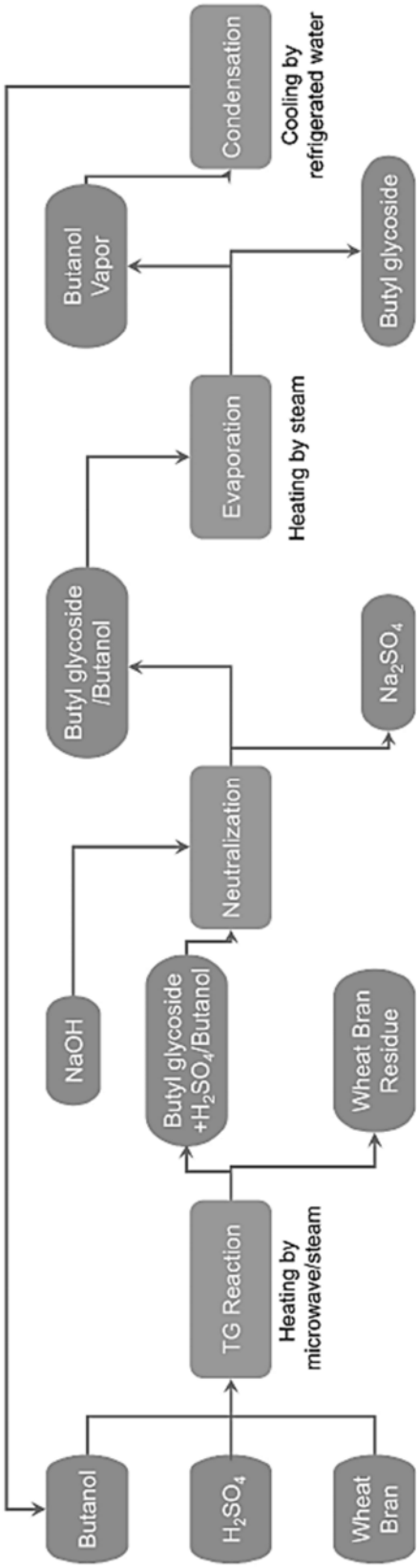

Butanol
H_2SO_4
Wheat Bran
TG Reaction
Heating by microwave/steam
NaOH
Butyl glycoside +H_2SO_4/Butanol
Wheat Bran Residue
Neutralization
Butyl glycoside /Butanol
Na_2SO_4
Evaporation
Heating by steam
Butanol Vapor
Butyl glycoside
Condensation
Cooling by refrigerated water

Figure 2

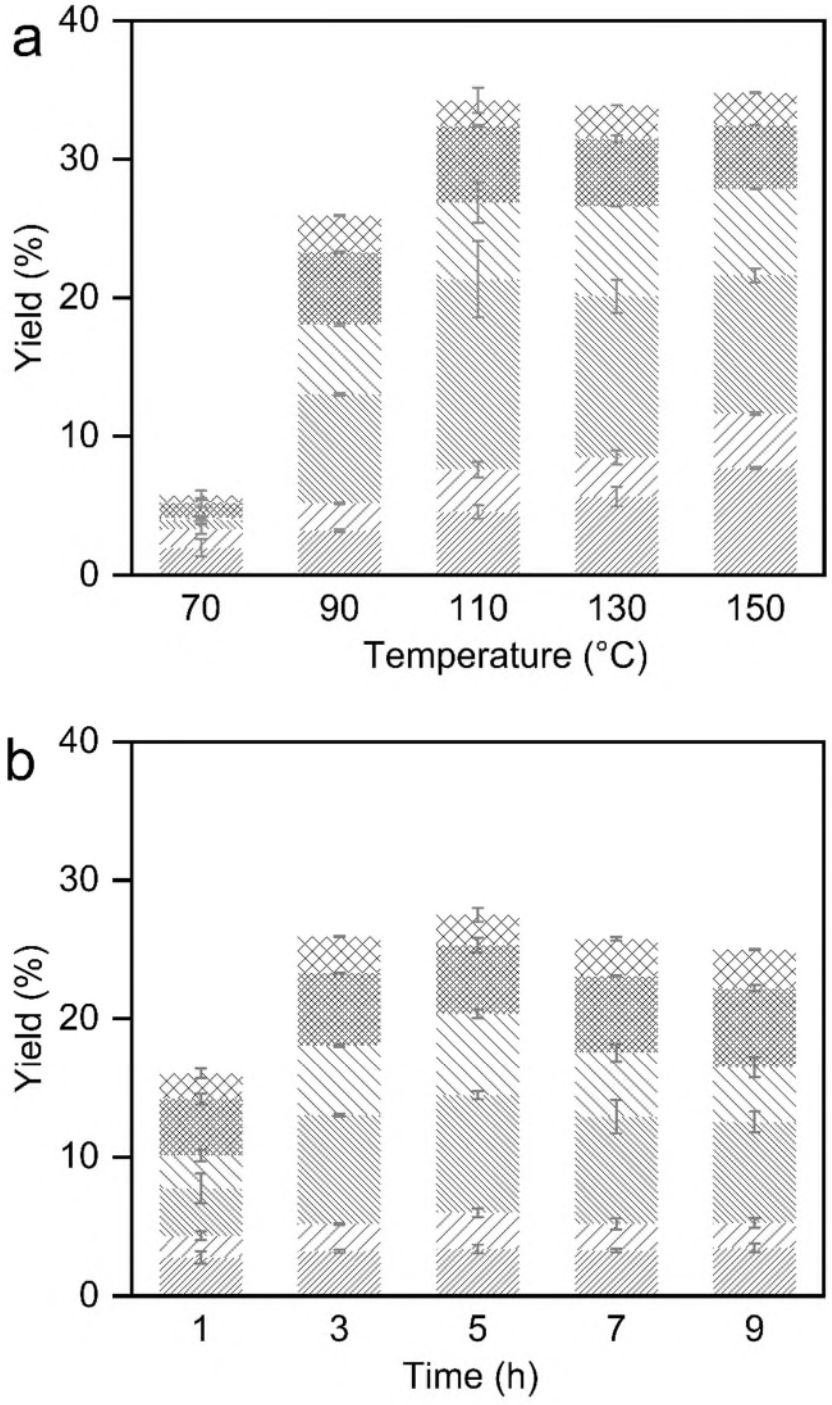

a
40
30
20
10
0
Yield (%)
70
90
110
130
150
Temperature (°C)
b
40
30
20
10
0
Yield (%)
1
3
5
7
9
Time (h)

Figure 3

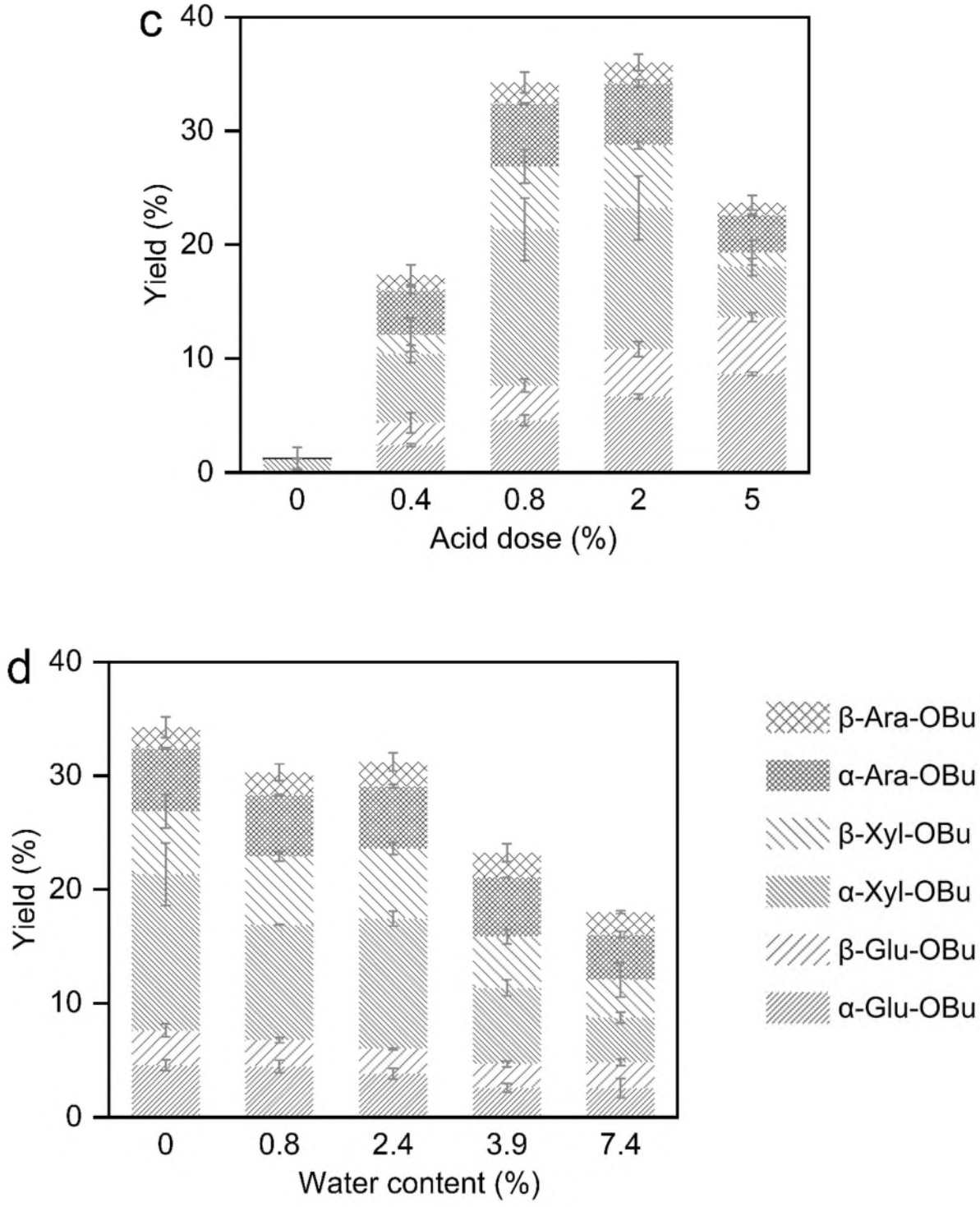


Figure 3 (continued)

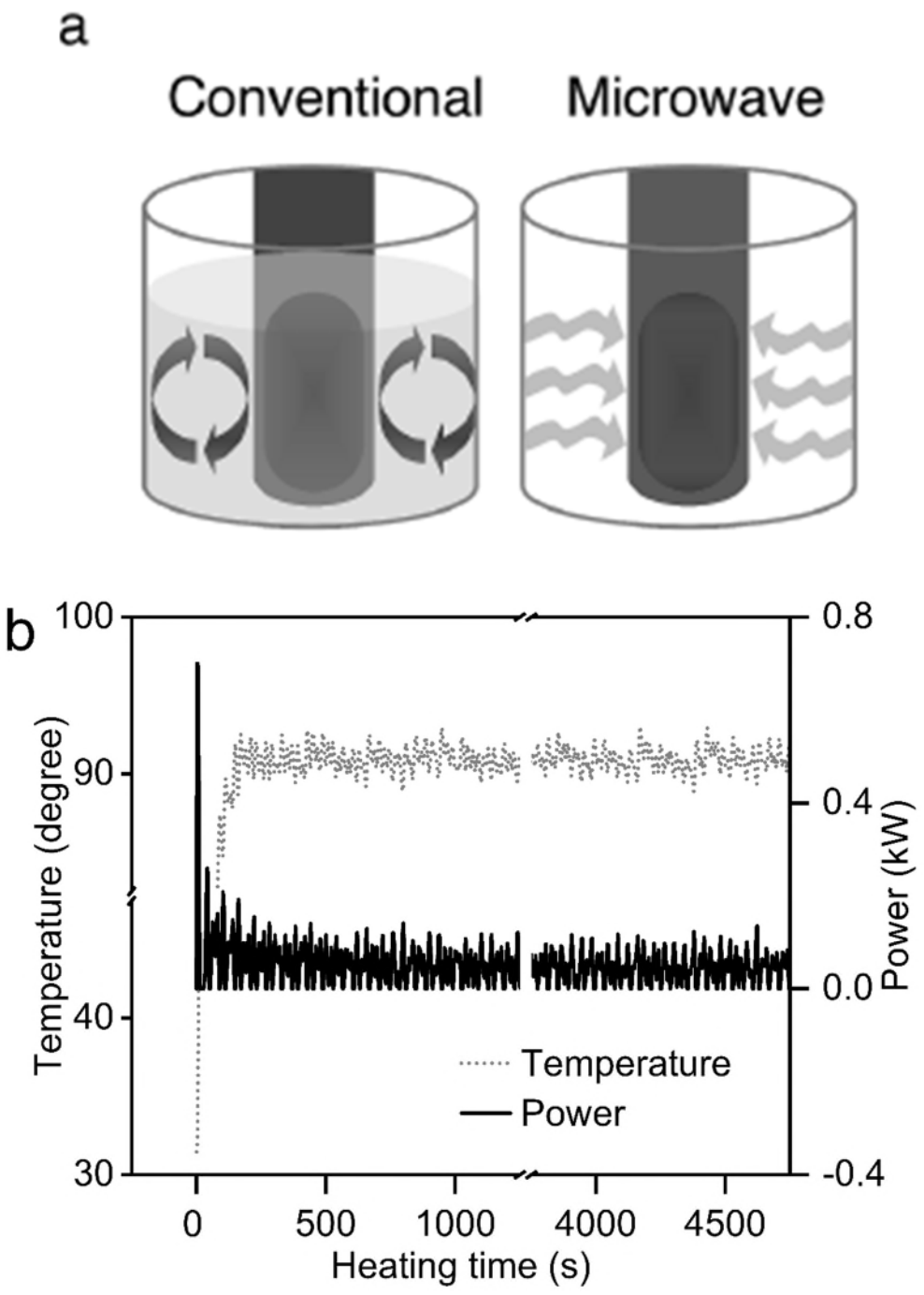

a
Conventional
Microwave
b
100
90
40
30
0.8
0.4
0.0
-0.4
Temperature (degree)
Power (kW)
Temperature
Power
0
500
1000
4000
4500
Heating time (s)

Figure 4

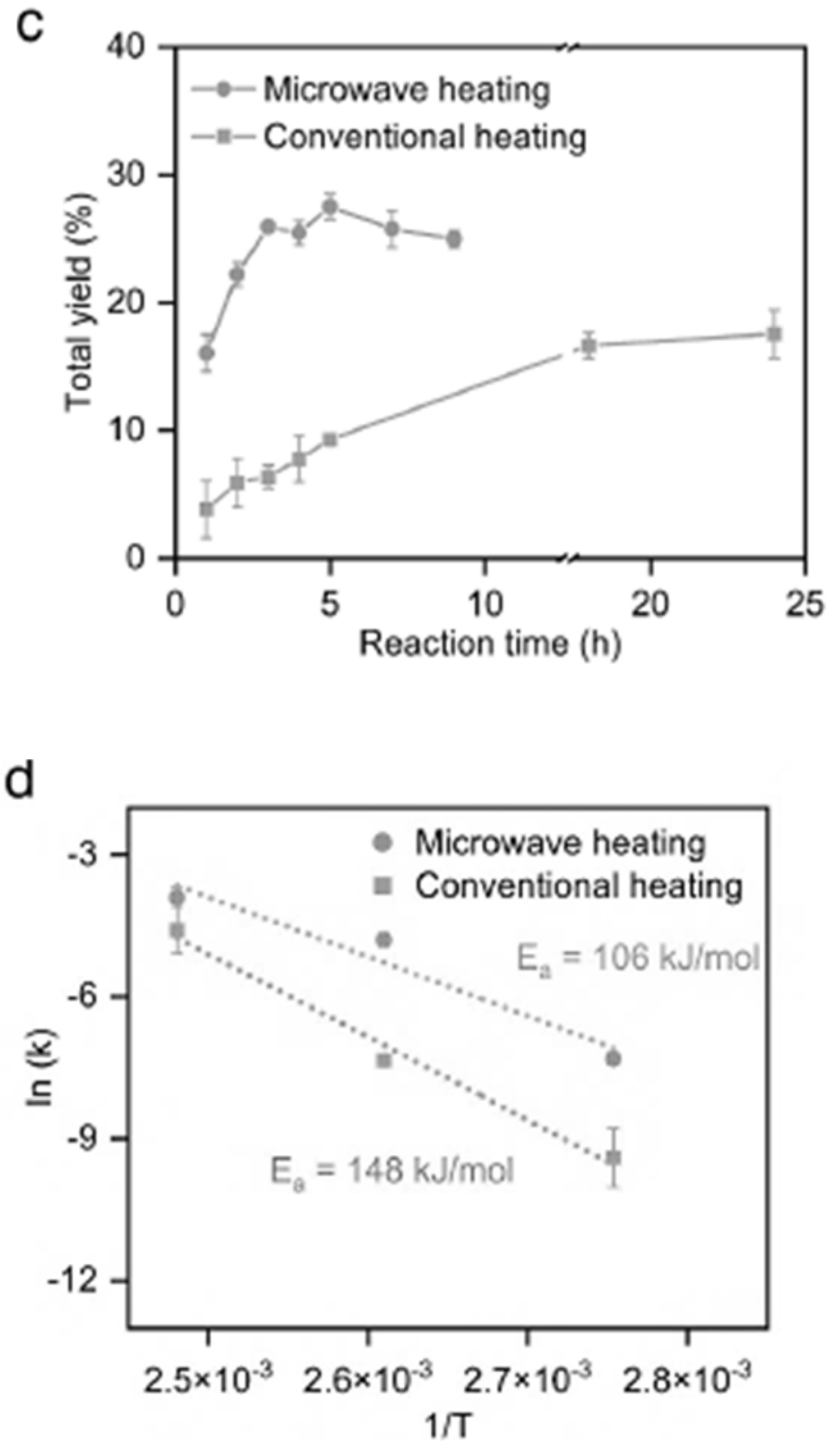


Figure 4 (continued)

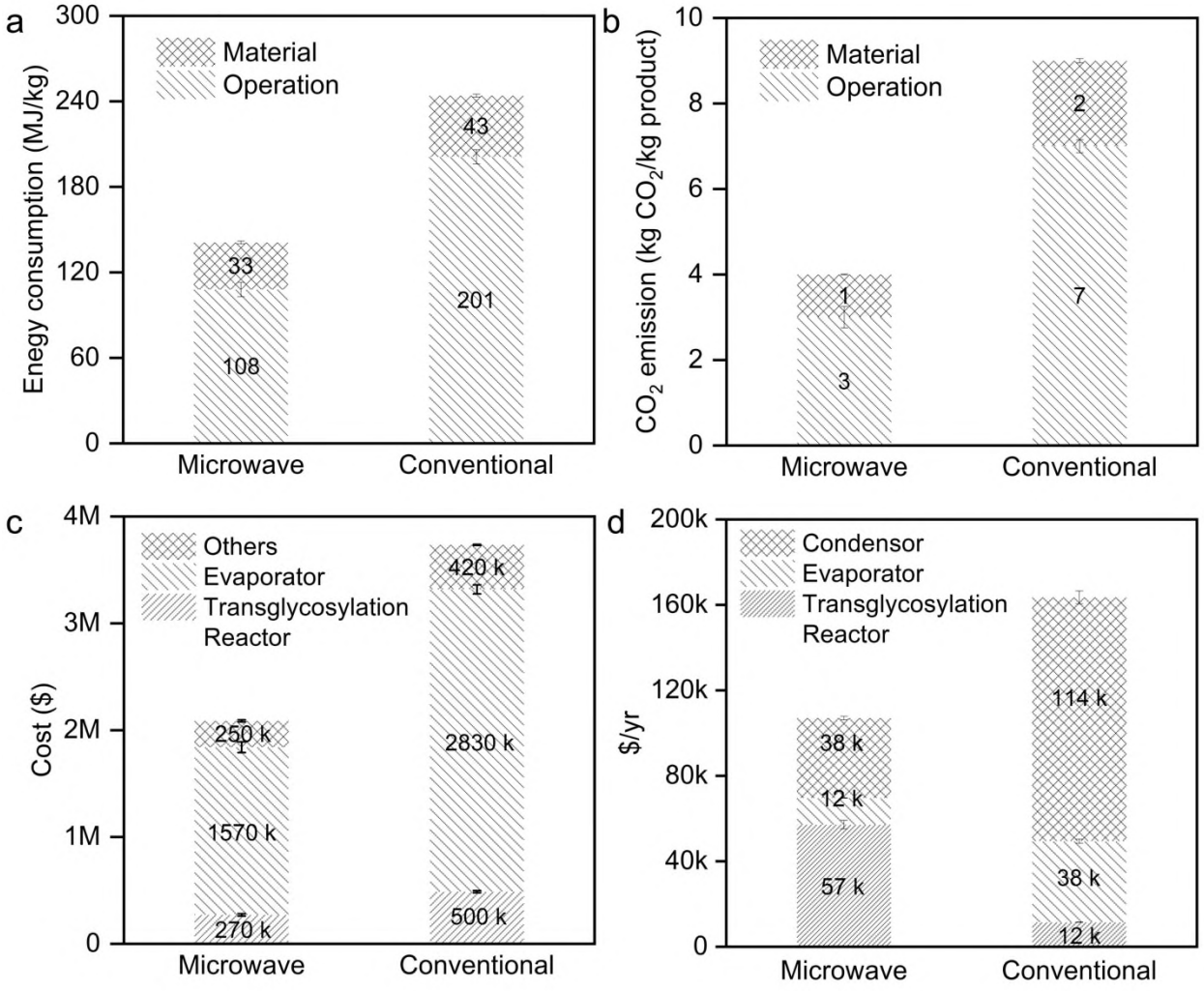

a
Enegy consumption (MJ/kg)
300
240
180
120
60
0
Material
Operation
33
108
43
201
Microwave
Conventional
b
CO_2 emission (kg CO_2/kg product)
10
8
6
4
2
0
Material
Operation
1
3
2
7
Microwave
Conventional
c
Cost ($)
4M
3M
2M
1M
0
Others
Evaporator
Transglycosylation
Reactor
250 k
1570 k
270 k
420 k
2830 k
500 k
Microwave
Conventional
d
$/yr
200k
160k
120k
80k
40k
0
Condensor
Evaporator
Transglycosylation
Reactor
38 k
12 k
57 k
114 k
38 k
12 k
Microwave
Conventional

Figure 5

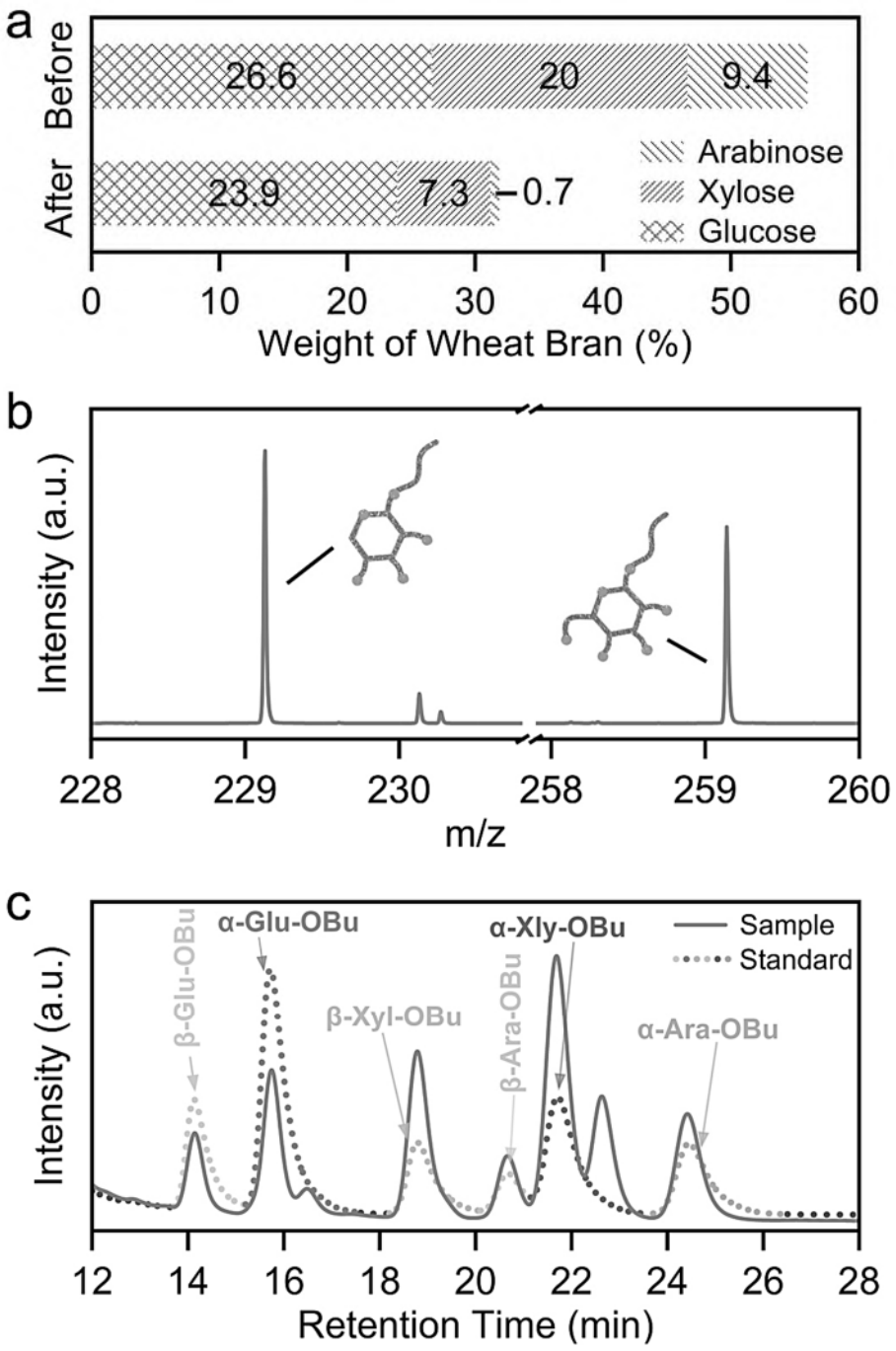

a
Before
After
26.6
20
9.4
23.9
7.3
−0.7
Arabinose
Xylose
Glucose
0
10
20
30
40
50
60
Weight of Wheat Bran (%)
b
Intensity (a.u.)
228
229
230
258
259
260
m/z
c
Intensity (a.u.)
β-Glu-OBu
α-Glu-OBu
β-Xyl-OBu
β-Ara-OBu
α-Xly-OBu
α-Ara-OBu
Sample
Standard
12
14
16
18
20
22
24
26
28
Retention Time (min)

Figure 6

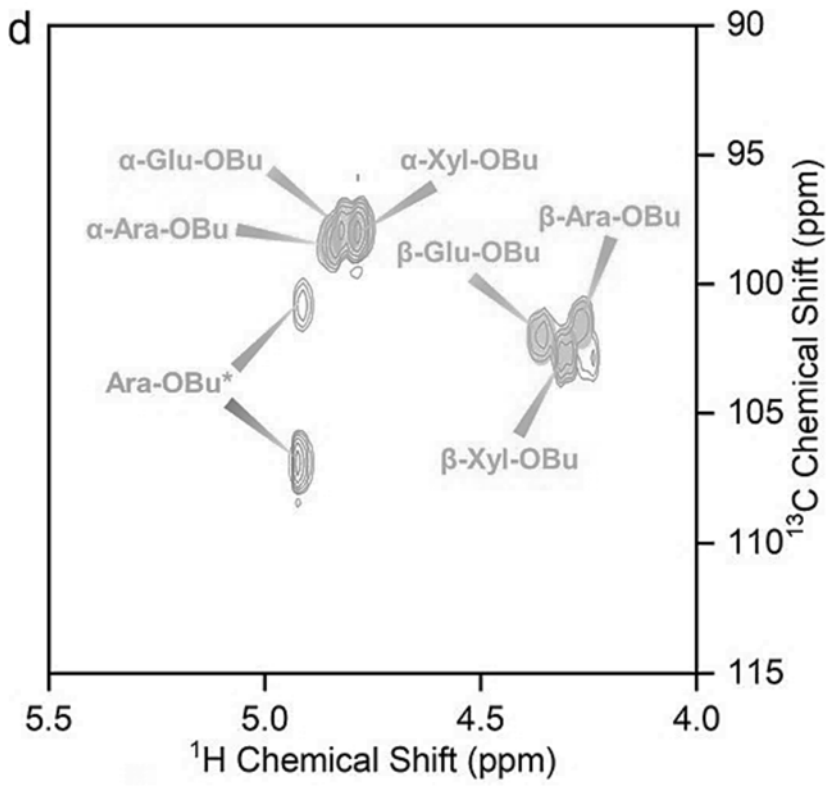


Figure 6 (continued)

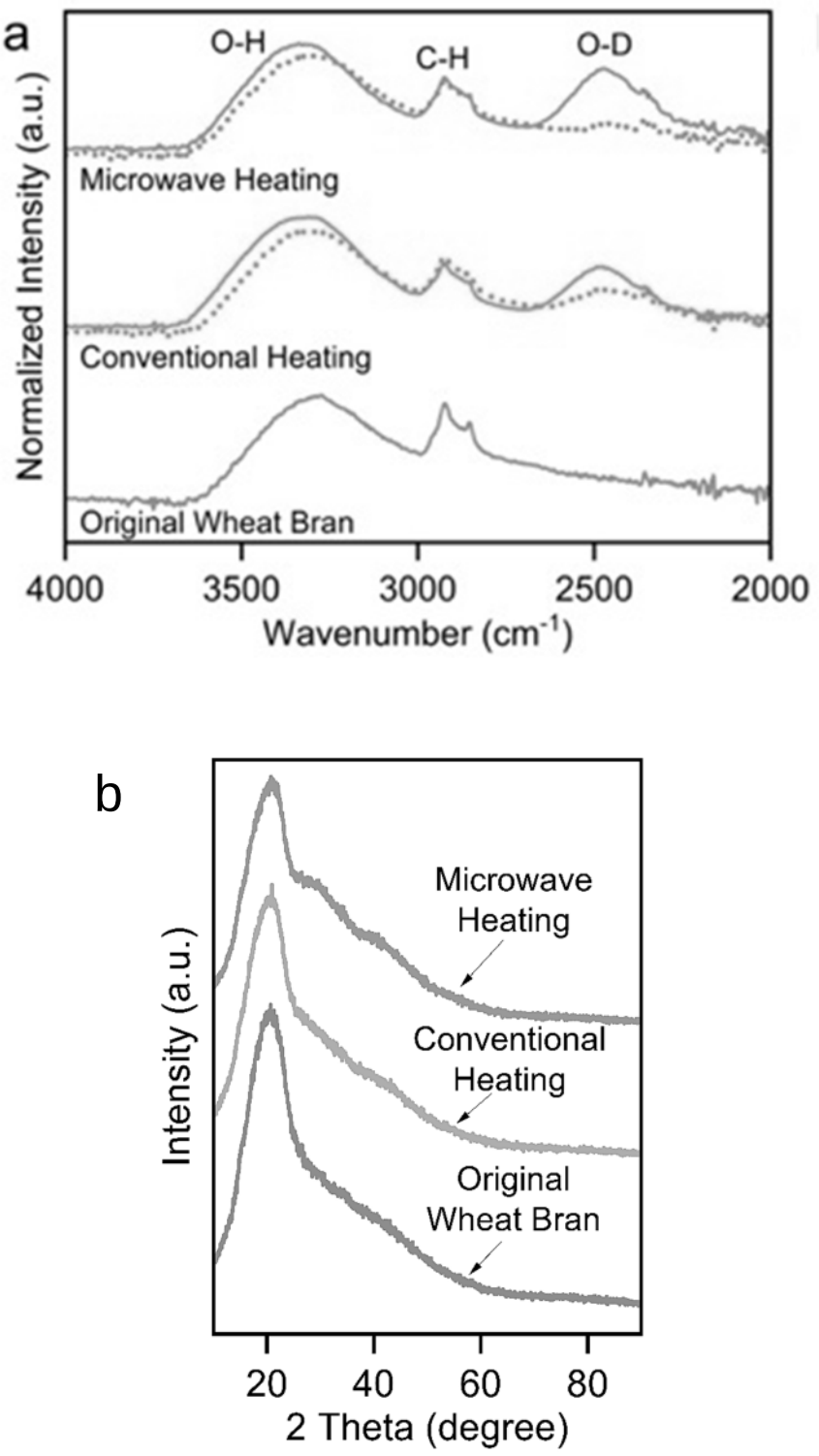
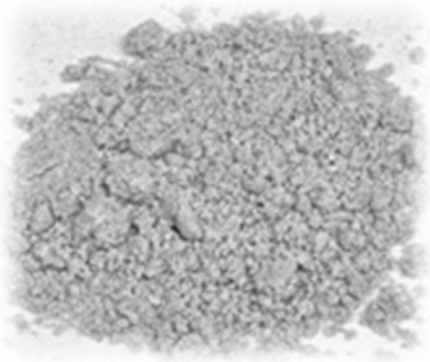
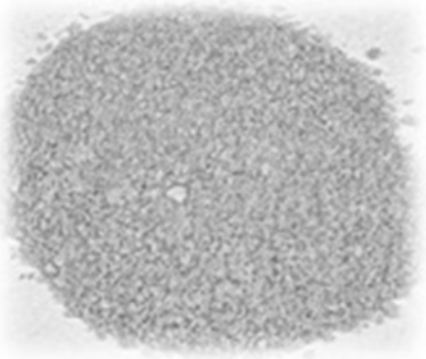

a
O-H
C-H
O-D
Microwave Heating
Conventional Heating
Original Wheat Bran
Normalized Intensity (a.u.)
4000
3500
3000
2500
2000
Wavenumber (cm-1)
b
Microwave Heating
Conventional Heating
Original Wheat Bran
Intensity (a.u.)
20
40
60
80
2 Theta (degree)

Figure 7

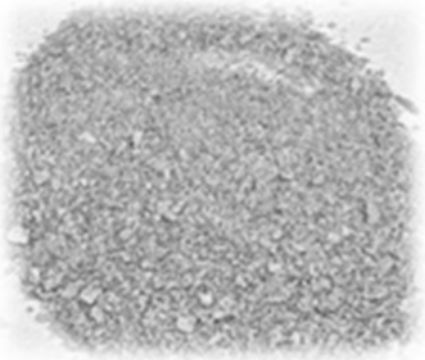
C



Original Wheat Bran



Conventional Heating



Microwave Heating

Figure 7 (continued)

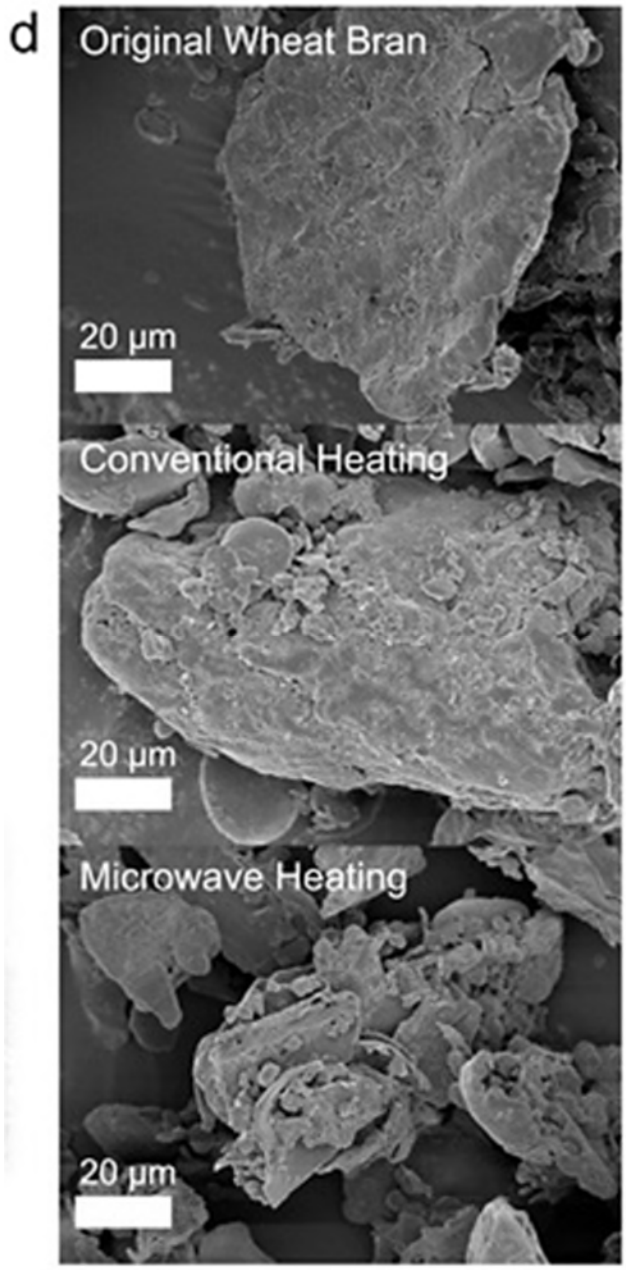


Figure 7 (continued)

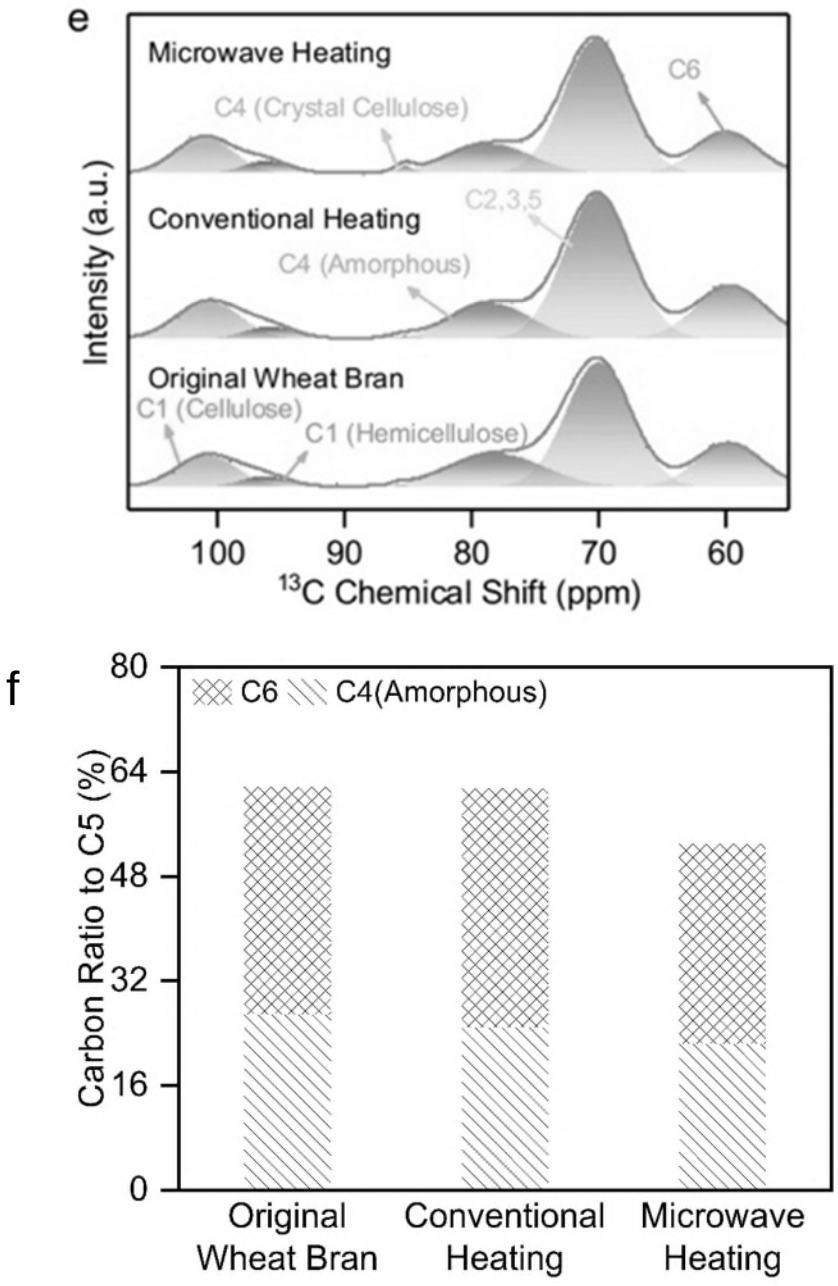


Figure 7 (continued)