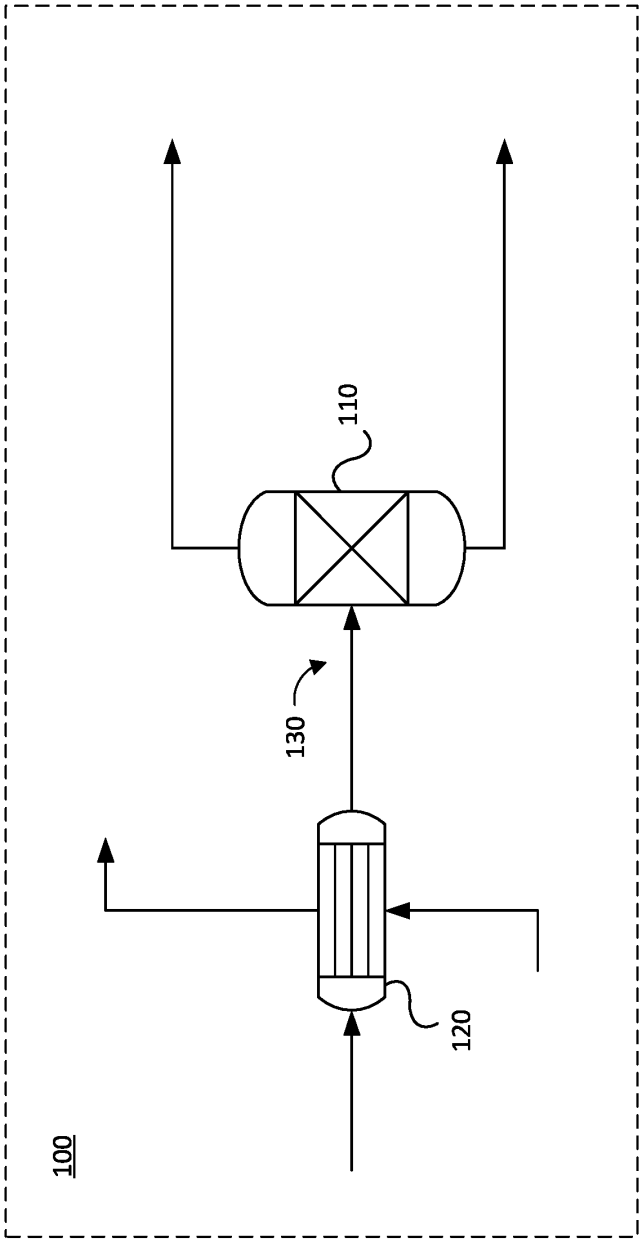



FIG. 1

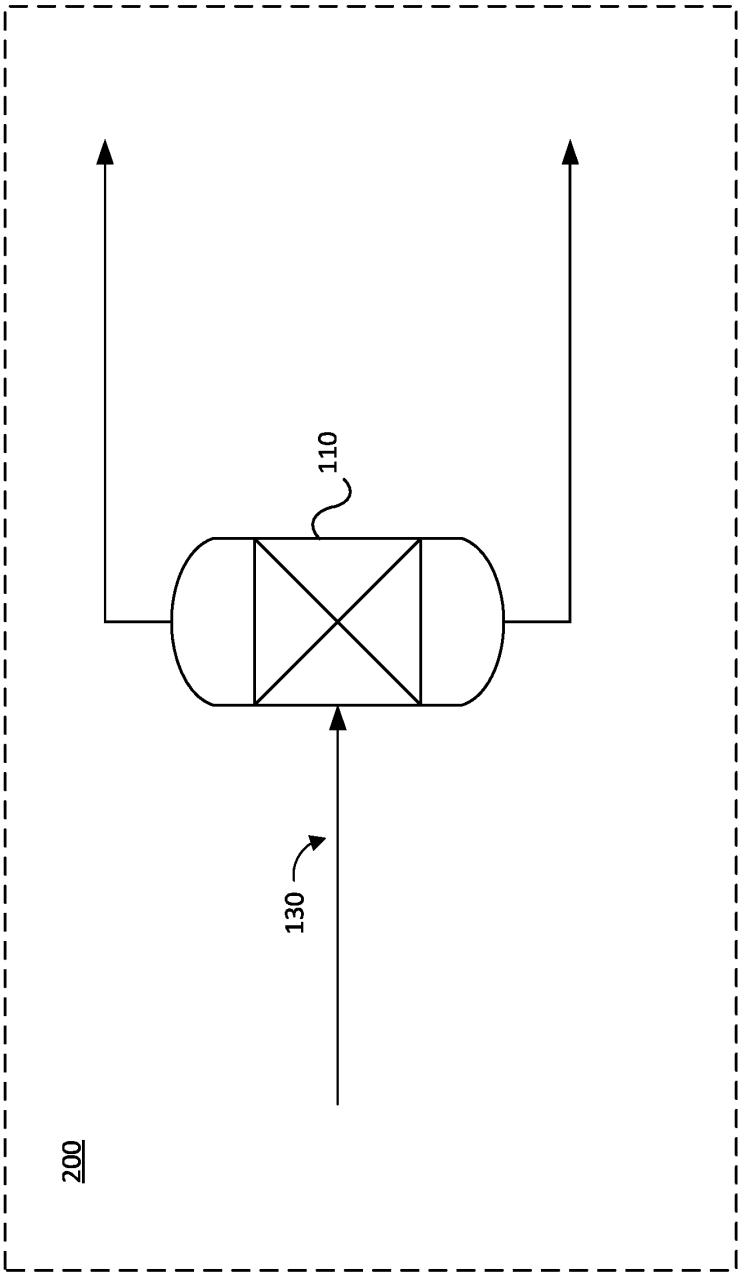



FIG. 2

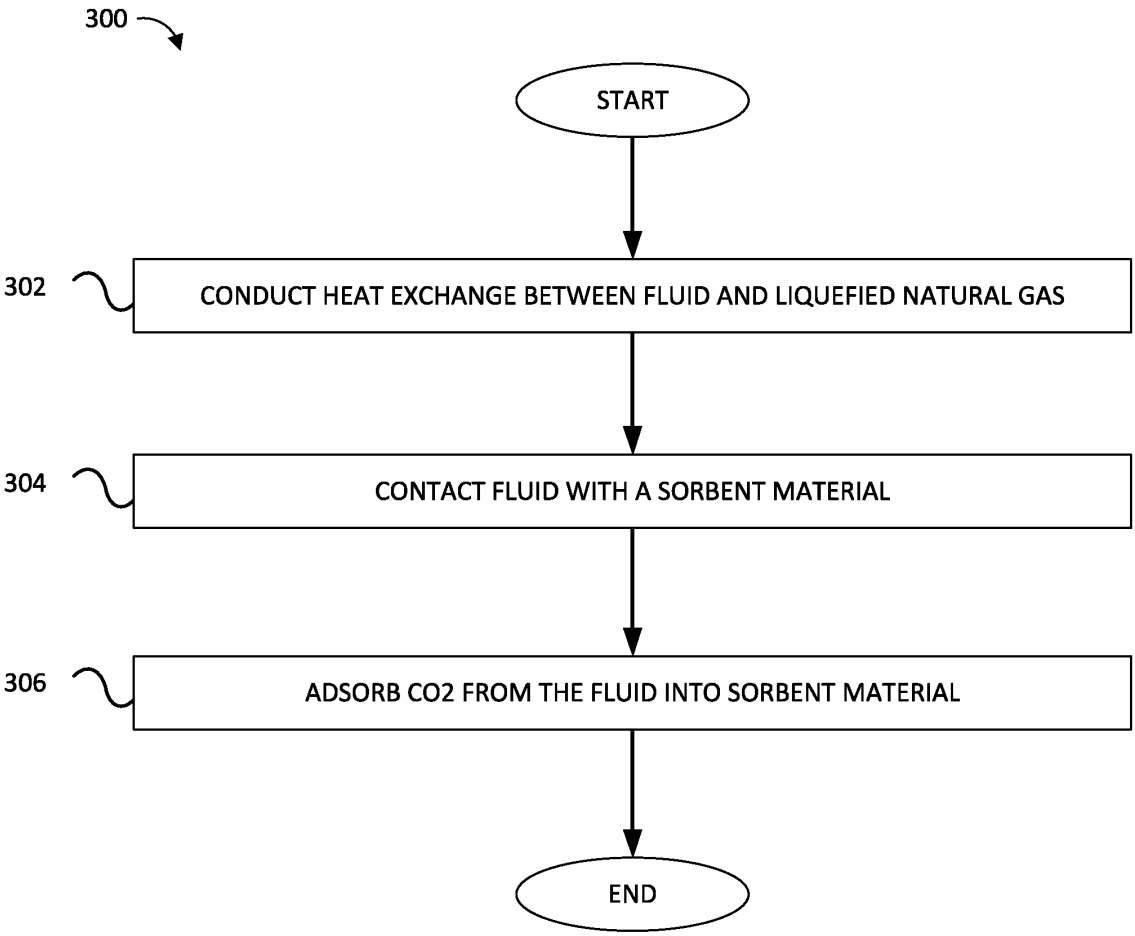

300
START
302
CONDUCT HEAT EXCHANGE BETWEEN FLUID AND LIQUEFIED NATURAL GAS
304
CONTACT FLUID WITH A SORBENT MATERIAL
306
ADSORB CO2 FROM THE FLUID INTO SORBENT MATERIAL
END

*FIG. 3*

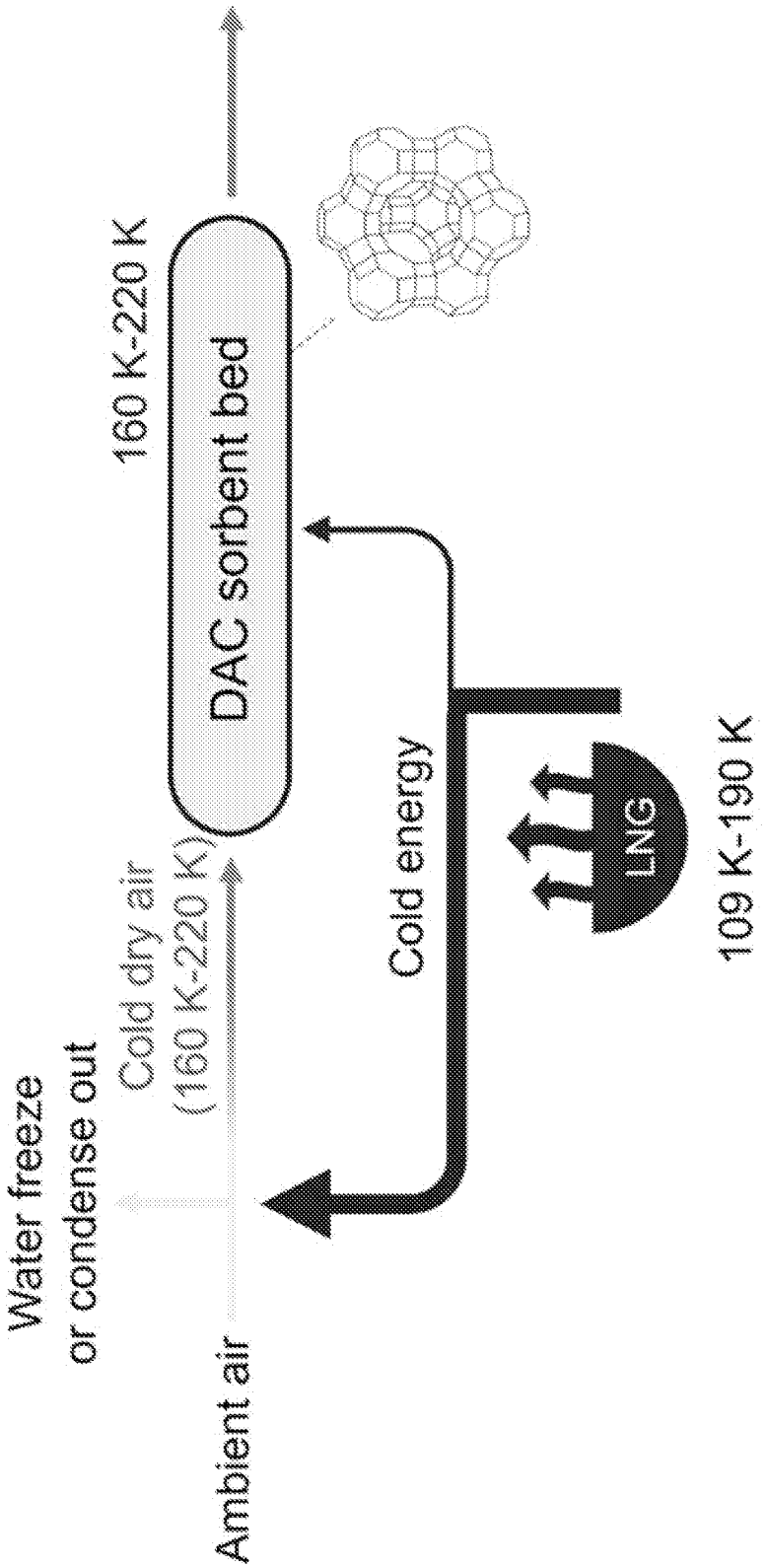

160 K-220 K
DAC sorbent bed
Cold energy
LNG
109 K-190 K
Water freeze
or condense out
Cold dry air
(160 K-220 K)
Ambient air

*FIG. 4A*

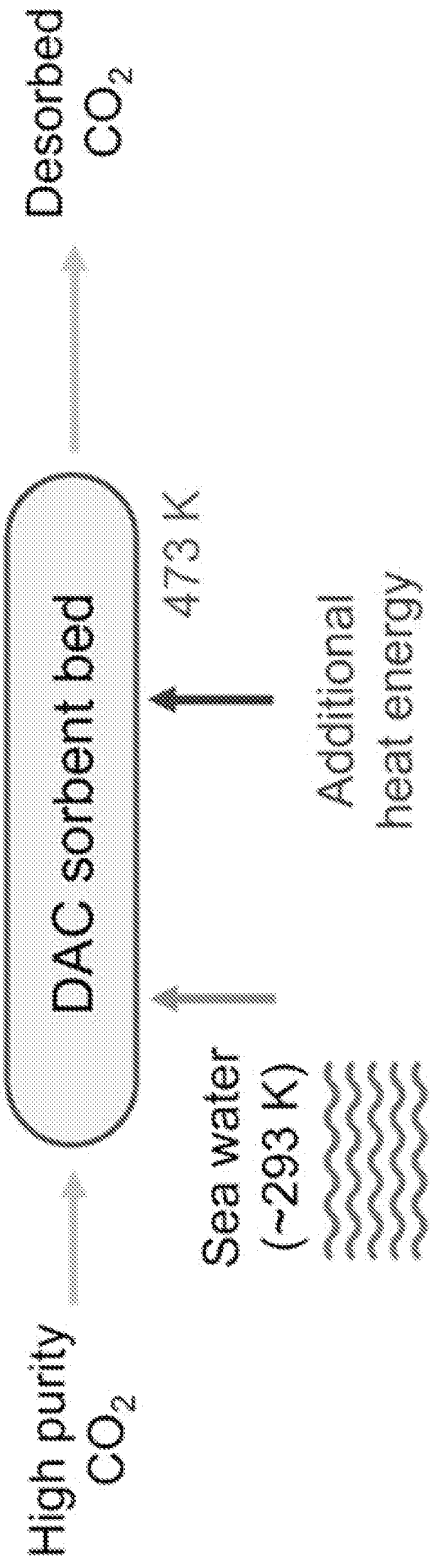

Desorbed
$CO_2$
DAC sorbent bed
473 K
Additional
heat energy
Sea water
(~293 K)
High purity
$CO_2$

*FIG. 4B*

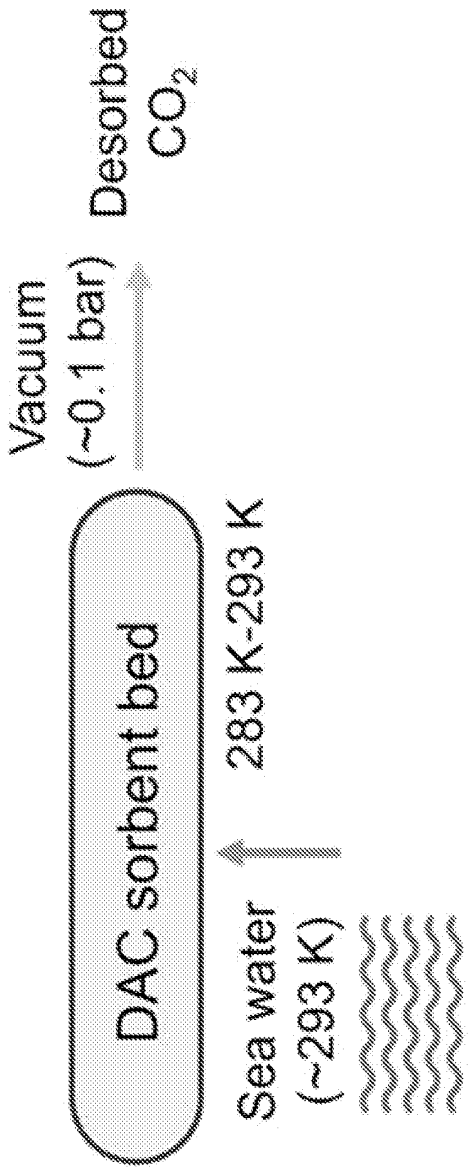

Desorbed
$CO_2$
Vacuum
(~0.1 bar)
DAC sorbent bed
283 K-293 K
Sea water
(~293 K)

*FIG. 4C*

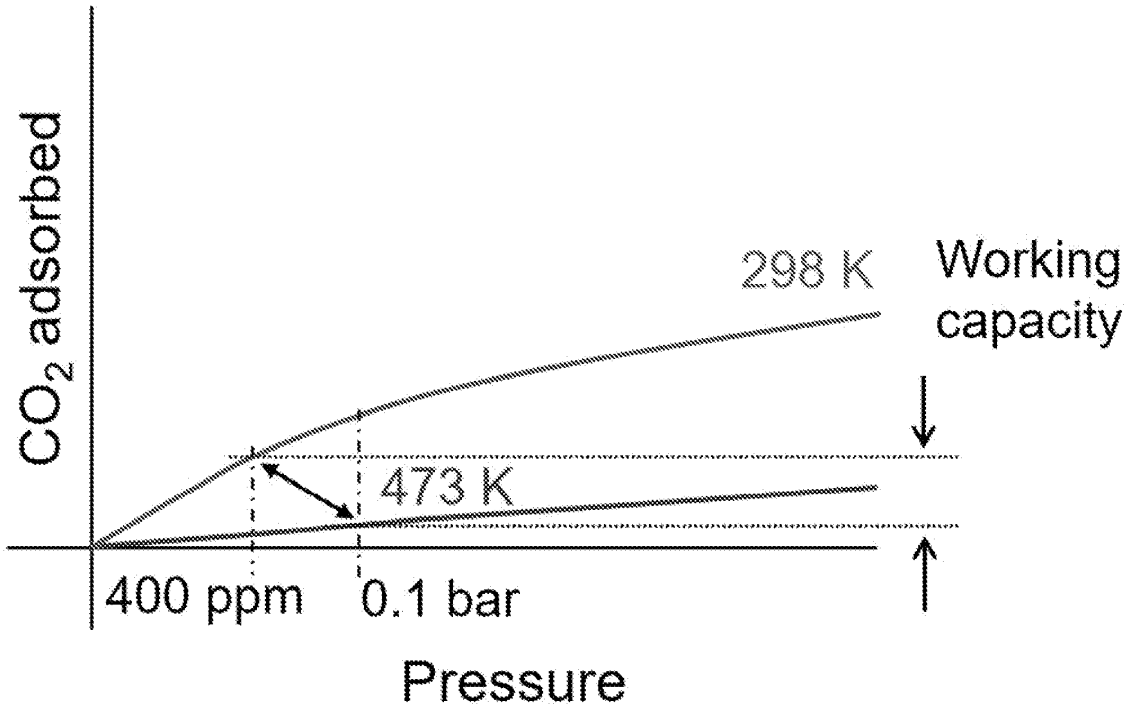

$CO_2$ adsorbed
298 K
Working capacity
473 K
400 ppm
0.1 bar
Pressure

*FIG. 5A*

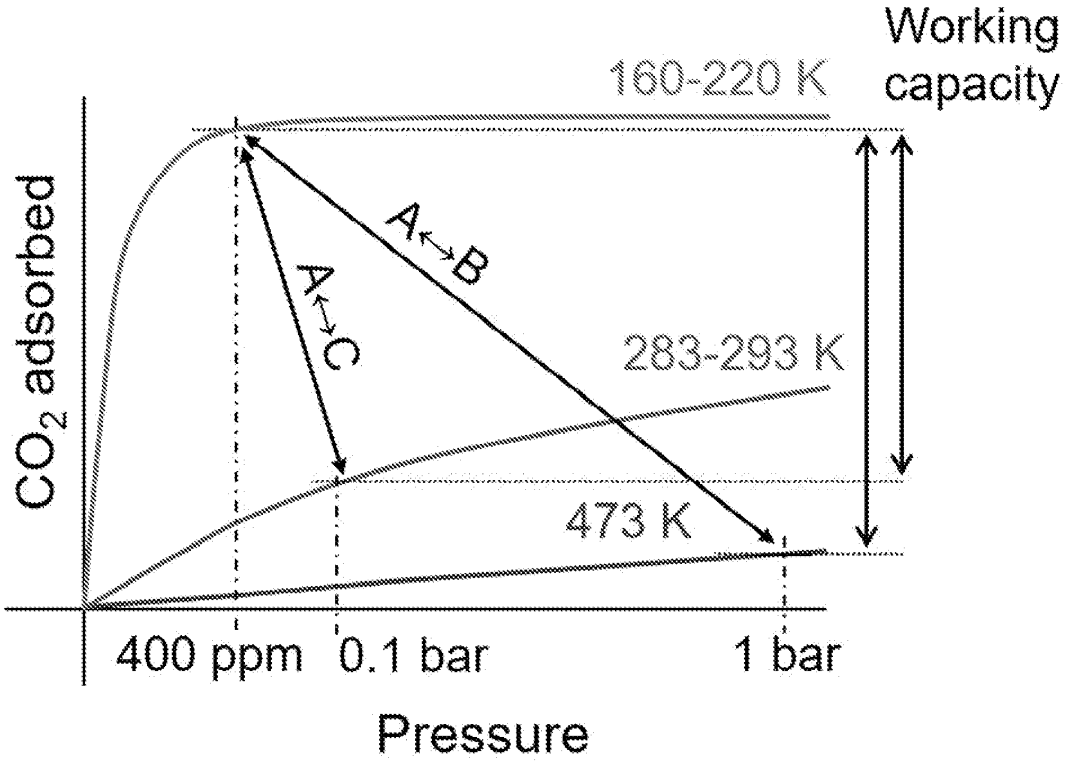

Working capacity
160-220 K
$CO_2$ adsorbed
A↔B
A↔C
283-293 K
473 K
400 ppm
0.1 bar
1 bar
Pressure

*FIG. 5B*

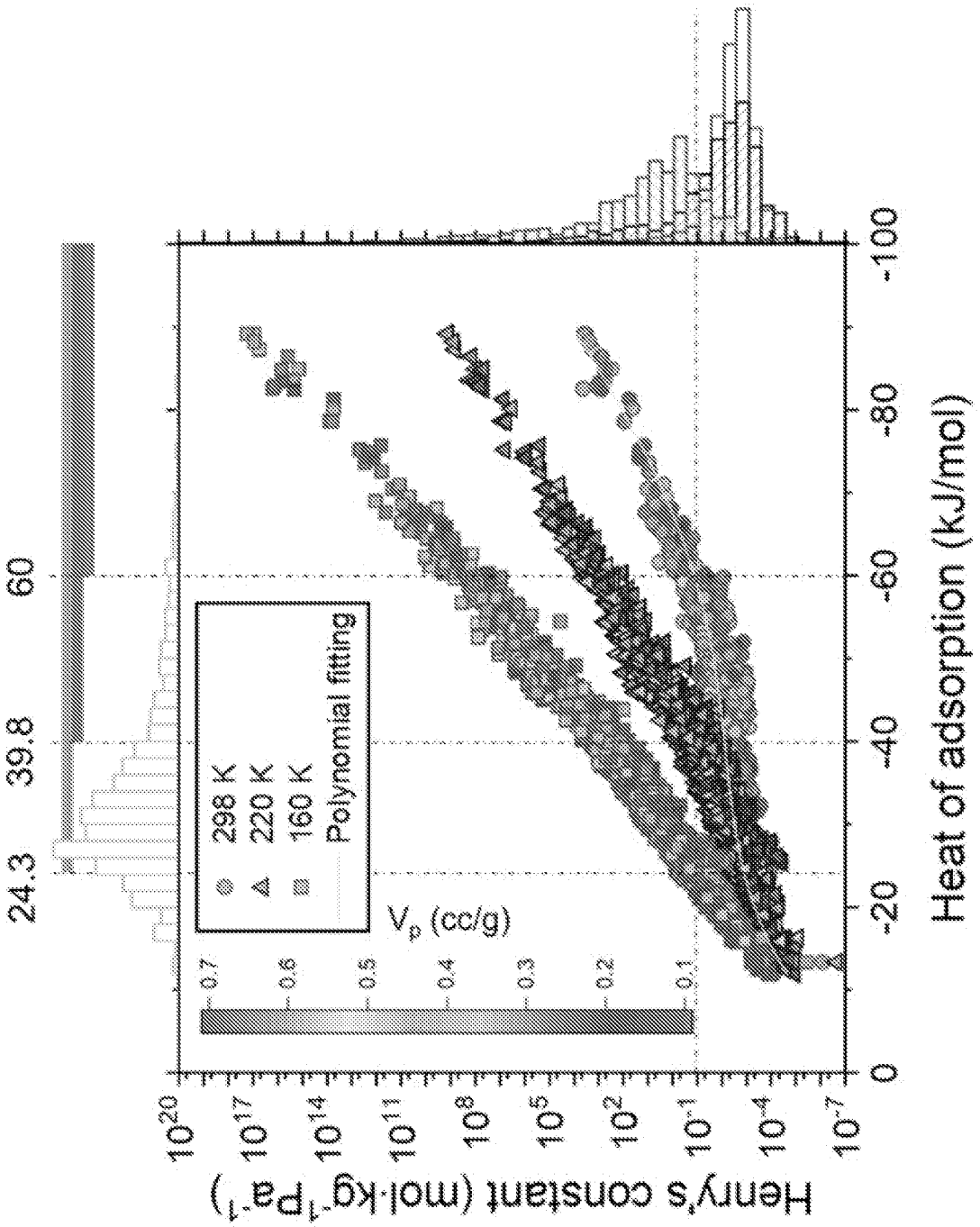

Heat of adsorption (kJ/mol)
0
-20
-40
-60
-80
-100
Henry's constant (mol·kg⁻¹Pa⁻¹)
10^20
10^17
10^14
10^11
10^8
10^5
10^2
10^-1
10^-4
10^-7
298 K
220 K
160 K
Polynomial fitting
V_p (cc/g)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
24.3
39.8
60

*FIG. 6*

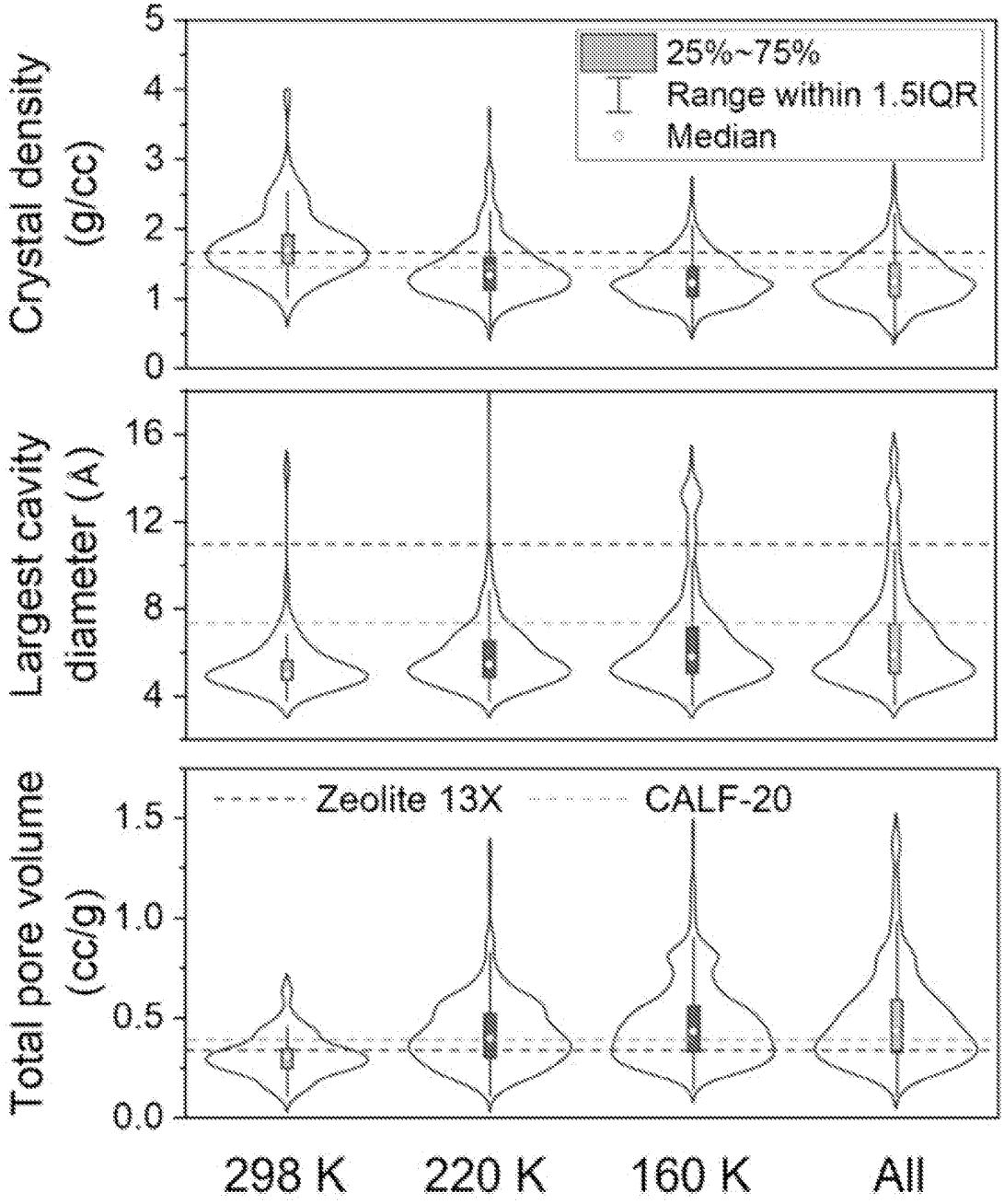

Crystal density (g/cc)
5
4
3
2
1
0
25%~75%
Range within 1.5IQR
Median
Largest cavity diameter (A)
16
12
8
4
Total pore volume (cc/g)
1.5
1.0
0.5
0.0
Zeolite 13X
CALF-20
298 K
220 K
160 K
All

*FIG. 7*

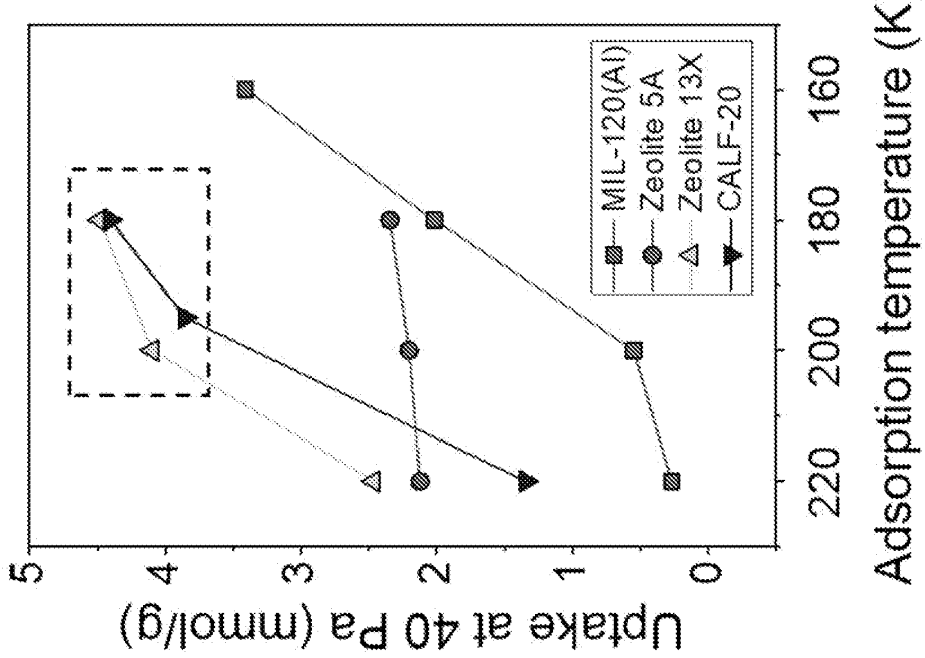

Uptake at 40 Pa (mmol/g)
Adsorption temperature (K)
MIL-120(Al)
Zeolite 5A
Zeolite 13X
CALF-20

FIG. 8A

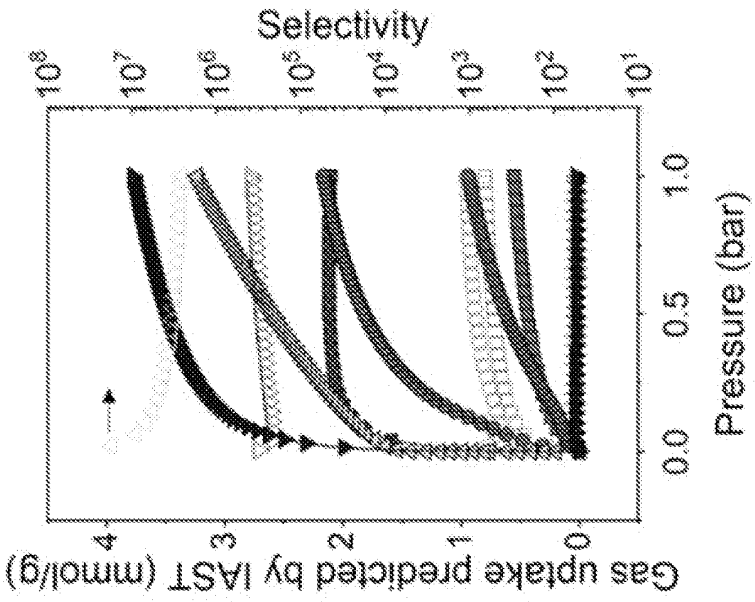

Gas uptake predicted by IAST (mmol/g)
Pressure (bar)
Selectivity

FIG. 8B

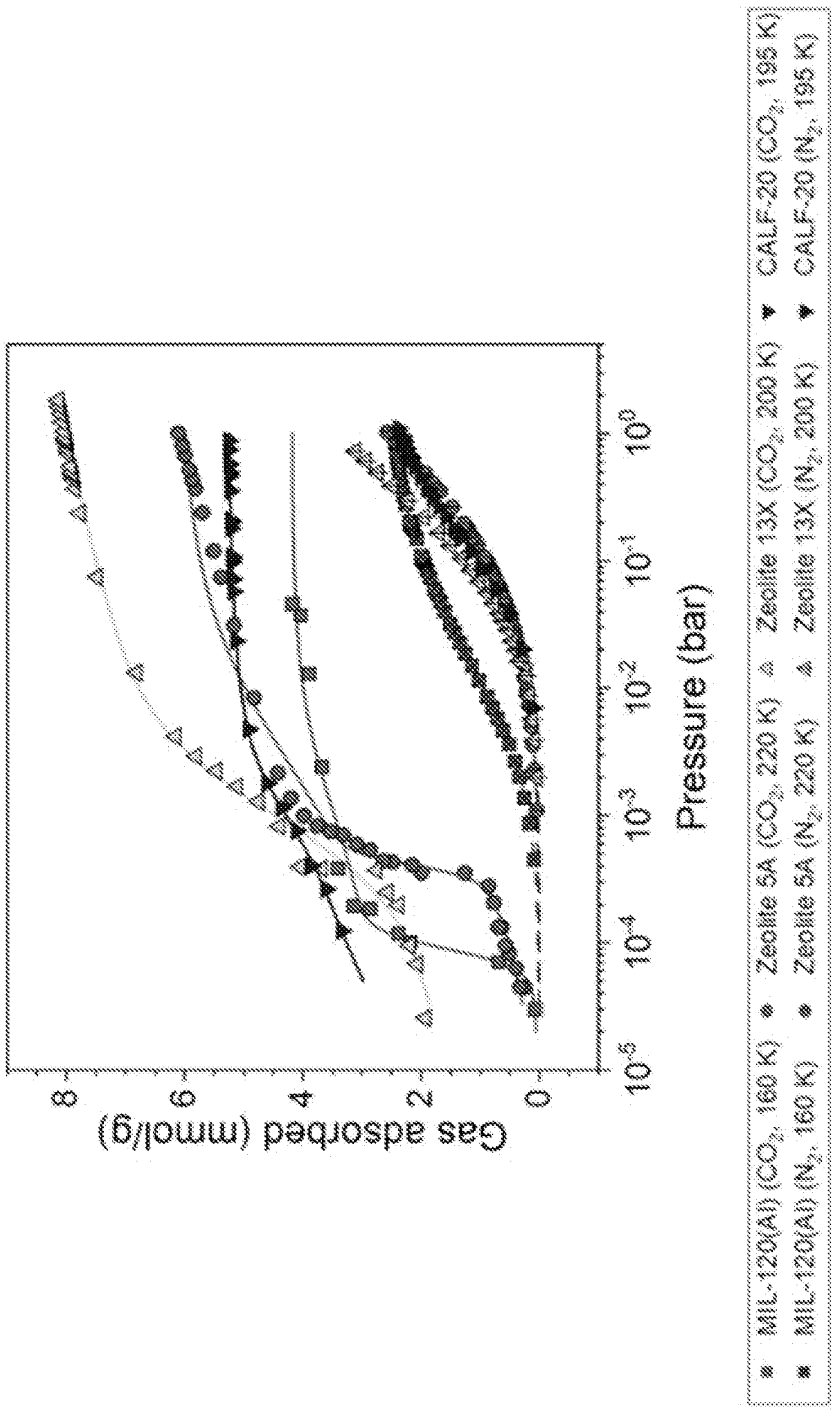

Gas adsorbed (mmol/g)
0
2
4
6
8
Pressure (bar)
$10^{-5}$
$10^{-4}$
$10^{-3}$
$10^{-2}$
$10^{-1}$
$10^{0}$
MIL-120(Al) ($CO_2$, 160 K)
Zeolite 5A ($CO_2$, 220 K)
Zeolite 13X ($CO_2$, 200 K)
CALF-20 ($CO_2$, 195 K)
MIL-120(Al) ($N_2$, 160 K)
Zeolite 5A ($N_2$, 220 K)
Zeolite 13X ($N_2$, 200 K)
CALF-20 ($N_2$, 195 K)

*FIG. 9*

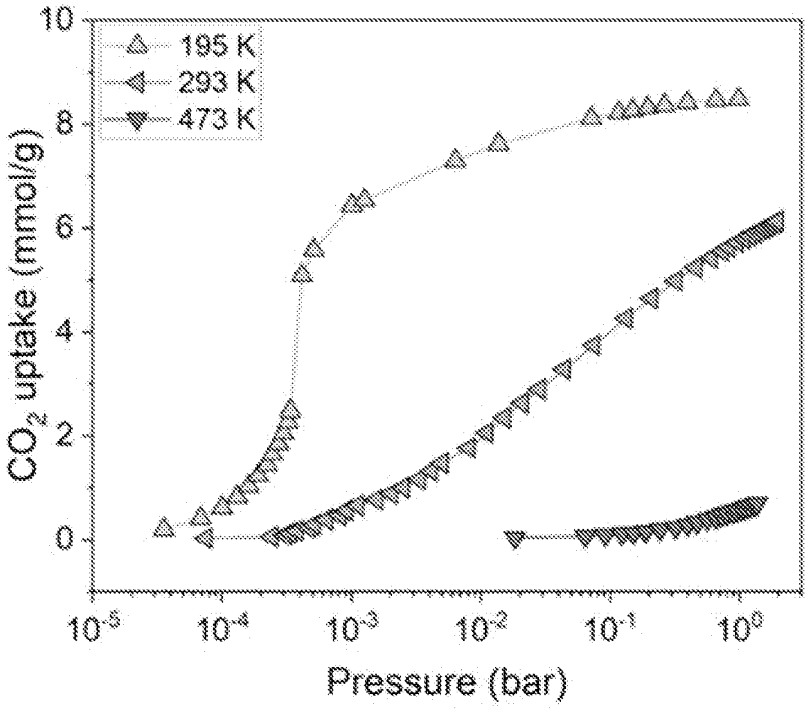



*FIG. 10A*

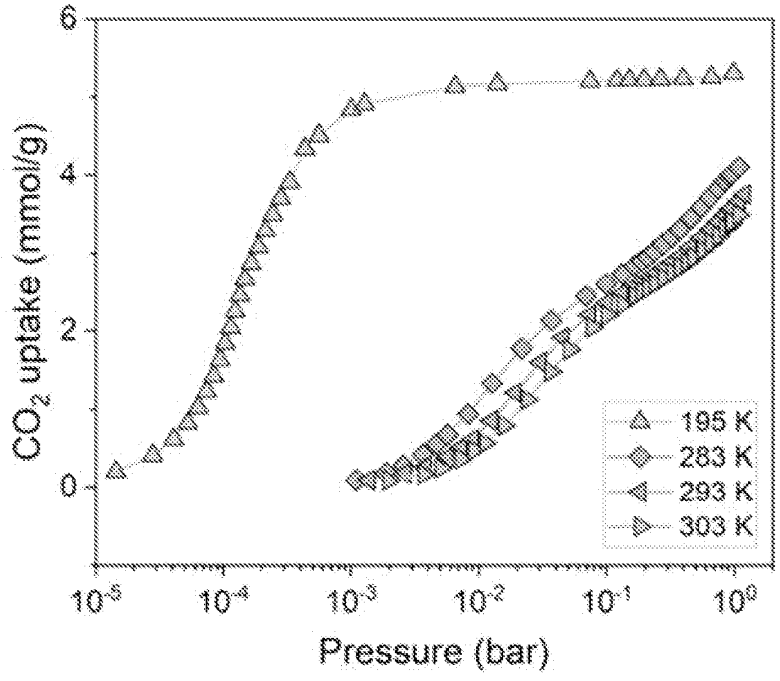



*FIG. 10B*

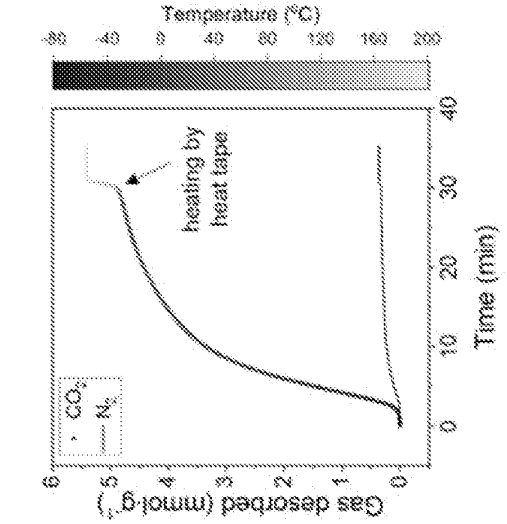



FIG. 11C

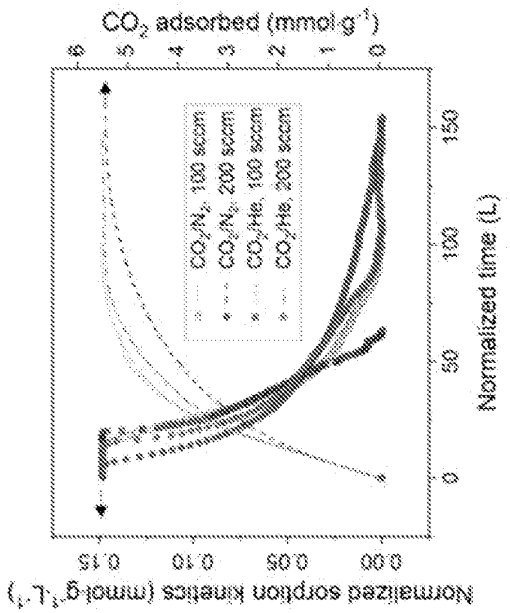



FIG. 11B

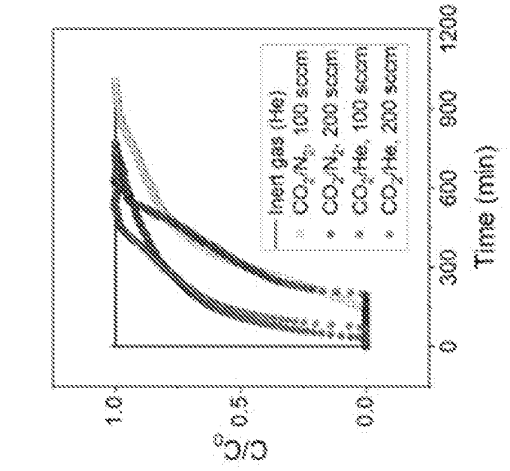



FIG. 11A

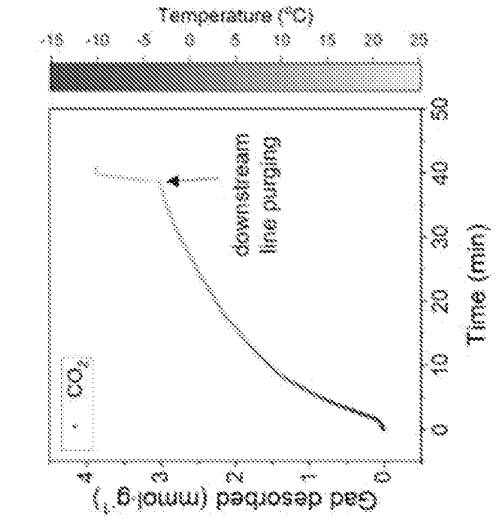



FIG. 12C

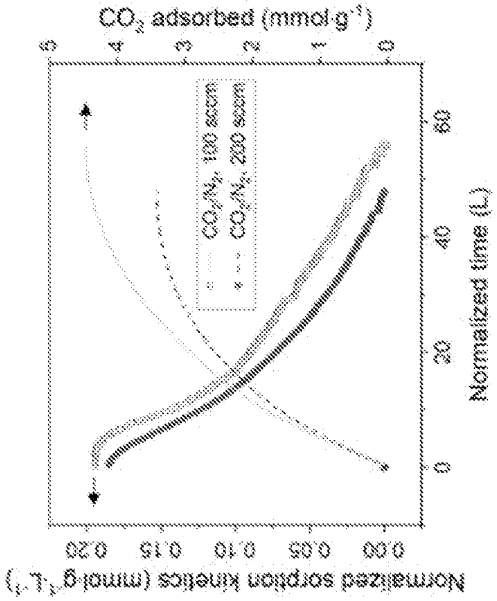



FIG. 12B

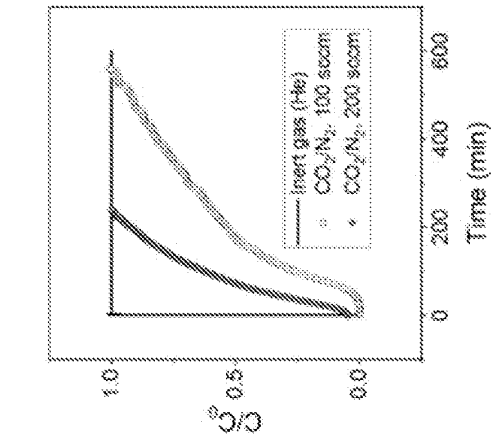



FIG. 12A