**Supplementary Information**

**Comparative Analysis of Amine-Functionalized Silica for Direct Air Capture (DAC): Material Characterization, Performance, and Thermodynamic Efficiency**

Riham Surkatti,1 Yasser M. Abdullatif ,1, 2 Raeesh Muhammad,1 Ahmed Sodiq,1 Kamal Mroue,3 Tareq Al-Ansari ,1,2 and Abdulkarem I. Amhamed\*1

1Qatar Environment and Energy Research Institute (QEERI), Hamad Bin Khalifa University, Qatar Foundation, Education City, Doha, Qatar

2College of Science and Engineering, Hamad Bin Khalifa University, Qatar Foundation, Doha, Qatar

3Core Laboratories, Hamad Bin Khalifa University, Qatar Foundation, Education City, Doha, Qatar

\*Corresponding author’s email: [aamhamed@hbku.edu.qa](mailto:aamhamed@hbku.edu.qa)

**A graph of a graph

Description automatically generated**

**Figure S1.** EDS spectrum of SBA-15.

**A graph of a graph of energy

Description automatically generated**

**Figure S2.** EDS spectrum of S-TEP.

**A graph of energy

Description automatically generated**

**Figure S3.** EDS spectrum of S-APT.

**A graph of a red line

Description automatically generated**

**Figure S4.** EDS spectrum of S-PEI-L.

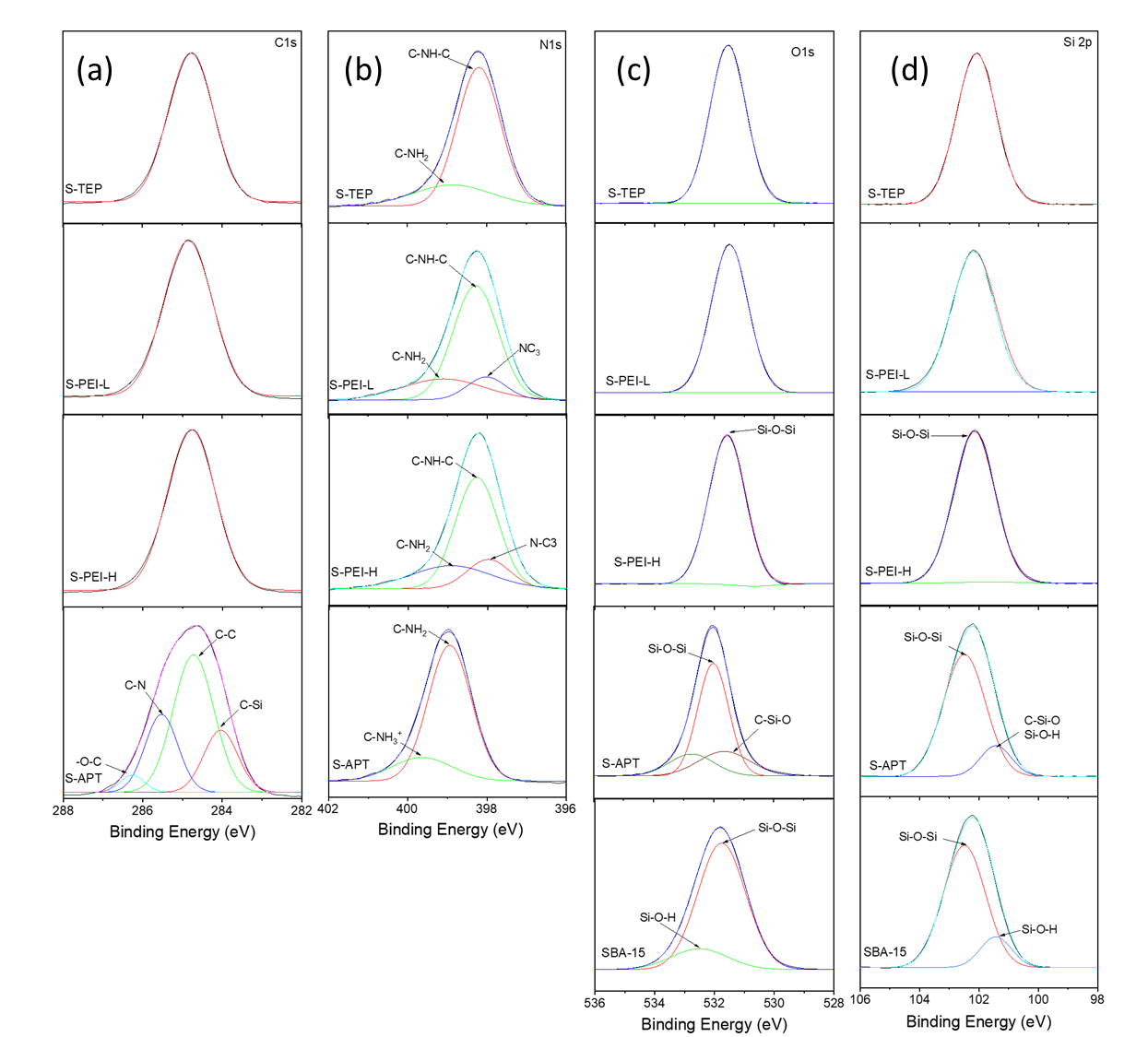
**A graph of a red line

Description automatically generated**

**Figure S5.** EDS spectrum of S-PEI-H.

**Table S1.** Atomic composition of the adsorbents analyzed by EDS.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample** | **C%** | **N%** | **O%** | **Si%** |
| **SBA-15** | - | - | 60 | 40 |
| **S-APT** | 44 | 12 | 29 | 15 |
| **S-PEI-L** | 28 | 11 | 41 | 20 |
| **S-PEI-H** | 35 | 16 | 35 | 14 |
| **S-TEP** | 38 | 19 | 30 | 13 |

****

**Figure S6.** High-resolution individual element XPS spectra: (a) C1s, (b) N1s, (c) O1s and (d) Si2p for SBA-15, S-TEP, S-APT, S-PEI-L and S-PEI-H.

**Table S2.** The fitted parameters for the kinetic models of CO2 adsorption under 50% humidity.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sample | Model | (mmol/g) | (min-1) |  |  |
| S-PEI-H | Avrami | 1.711 | 0.004 | 1.437 | 0.999 |
| S-PEI-L | Avrami | 3.007 | 0.001 | 1.433 | 0.995 |
| S-TEP | Avrami | 3.359 | 0.002 | 1.500 | 0.998 |

**Table S3.** The fitted parameters for the kinetic models of H2O adsorption under 50% humidity.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sample | Model | (mmol/g) | (min-1) |  |  |
| S-PEI-H | Avrami | 12.784 | 0.008 | 1.216 | 0.999 |
| S-PEI-L | Avrami | 10.426 | 0.006 | 0.988 | 0.995 |
| S-TEP | Avrami | 4.4356 | 0.026 | 1.154 | 0.998 |