**Investigating the adsorption behavior and mechanism of Eu(III) and Au(III) on β-cyclodextrin/polyethylenimine functionalized waste paper**

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**Table S1** Isotherms model constants for adsorption of Eu(III) and Au(III) on DAWP-PEI and DAWP-PEI-β-CD.

|  |  |  |  |
| --- | --- | --- | --- |
| Adsorbent | Metal ions | Langmuir parameters[1] | Freundlich parameters[2] |
| qexp | qmax | b | R2 | k | 1/n | R2 |
| DAWP-PEI | Eu(III) | 205.3 | 206.9 | 0.124 | 0.994 | 53.73 | 0.348 | 0.914 |
| Au(III) | 394.4 | 403.8 | 0.195 | 0.981 | 130.8 | 0.287 | 0.831 |
| DAWP-PEI-*β*-CD | Eu(III) | 242.2 | 244.6 | 0.486 | 0.983 | 170.8 | 0.104 | 0.743 |
| Au(III) | 424.2 | 423.6 | 0.961 | 0.986 | 213.6 | 0.193 | 0.797 |

[1] Langmuir equation: qe = qmax b Ce / (1+bCe); [2] Freundlich equation: qe = k Ce1/n

**Table S2** Calculated thermodynamic parameters from the thermodynamic equations.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Metal ions  | Temperature (K) | △Go (kJ.mol-1) | △Ho (kJ.mol-1) | △So (J/mol-1.K-1) |
| Eu(III) | 298 | -3.139 | 45.64 | 182.9 |
| 308 | -3.764 |  |  |
| 318 | -4.150 |  |  |
| Au(III) | 298 | -13.65 | 25.84 | 130.1 |
| 308 | -15.26 |  |  |
| 318 | -16.23 |  |  |

△Go =△Ho-T△So; △Go = -RTlnKc; Kc=qe/Ce

**Table S3** Comparison of Eu(III) and Au(III) elimination by DAWP-PEI-β-CD and other adsorption materials.

|  |  |  |
| --- | --- | --- |
| Sorbents | Adsorption capacity (mg/g) | Refs |
| Eu(III) | Au(III) |
| DAWP-PEI-β-CD | 241.3 | 424.2 | This work |
| Graphene oxide | 83.5 | - | (Ma et al., 2019) |
| Viscose fiber | - | 535 | (Liu et al., 2020) |
| EDTA-β-CD | 55.2 | - | (Zhao et al.,2016) |
| Tannin acid | - | 298.5 | (Liu et al., 2019) |
| Fe3O4/PDA | 151.1 | - | (Fang et al.,2017) |
| Resin | - | 920 | (Chen et al., 2020) |
| Al2O3 | 5.14 | - | (Sun et al., 2012) |

**Table S4** Kinetics model constants for adsorption of Eu(III) and Au(III) on DAWP-PEI-*β*-CD.

|  |  |  |
| --- | --- | --- |
| Metal ions | Pseudo-first-order parameters [1] | Pseudo-second-order parameters [2] |
| qe (mg/g) | kf (h-1) | R2 | qe (mg/g) | ks (g/mg/h) | R2 |
| Eu(III) | 206.8 | 0.168 | 0.898 | 221.5 | 0.013 | 0.993 |
| Au(III) | 218.1 | 0.469 | 0.844 | 222.4 | 0.224 | 0.995 |
| Metal ions | Intraparticle diffusion model[3] |
| k1(mg/g/h0.5) | R2 | k2(mg/g/h0.5) | R2 | k3(mg/g/h0.5) | R2 |
| Eu(III) | 109.4 | 0.999 | 44.18 | 0.960 | 4.779 | 0.838 |
| Au(III) | 164.7 | 0.999 | 33.57 | 0.944 | 2.732 | 0.992 |

[1]Pseudo-first-order equation:；[2] Pseudo-second-order equation:

 [3]Intraparticle diffusion equation:$ q\_{t}=k\_{i}t^{0.5}+C$

**Table S5** Contents (atom %) of elements and metal ions on DAWP-PEI-β-CD, DAWP-PEI-β-CD-Eu and DAWP-PEI-β-CD-Au calculated from XPS analysis.

|  |  |  |
| --- | --- | --- |
| Adsorbent | Contents of elements (atom %) | Percent of metal and ions (atom%) |
| C | O | N | Au | Eu | Au(III) | Au(0) | Eu(III) | Eu(0) |
| DAWP-PEI-β-CD | 56.46 | 35.34 | 8.19 | - | - | - | - | - | - |
| DAWP-PEI-β-CD-Eu | 39.23 | 51.66 | 4.80 | - | 4.31 | - | - | 100 | - |
| DAWP-PEI-β-CD-Au | 48.88 | 40.67 | 8.89 | 1.56 | - | 45.35 | 54.65 | - | - |



**Fig. S1** Zeta potential values of DAWP-PEI-β-CD at different pH values.



**Fig. S2** Effect of co-existing pollutants on the removal of Eu(III) and Au(III) by DAWP-PEI-β-CD. (Adsorbent=10 mg; Ci =50 mg/ L for all metal ions; V=50 mL; pH=2.0; T=298 K).