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Herein, through coordination-based post-synthetic strategy, microporous-mesoporous Zn-MOF-74 was easily functionalized by grafting coumarin on coordinatively unsaturated Zn(II) centers, yielding a series of coumarin-modified Zn-MOF-74 materials. The obtained samples afforded ultra-high adsorption capacity for U^{VI} ions from water with maximum adsorption capacities as high as 360 mg/g (the record value in MOFs) and remarkable photo-switched capability of 50 mg/g.

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Abstract: Driven by an energy crisis but consequently puzzled by various environmental problems, uranium, as the basic material of nuclear energy, is now receiving extensive attentions. In contrast to numerous sorbents applied in this field, metal-organic framework (MOFs), as a renovated material platform, has only recently been developed. How to improve the adsorption capacity of MOF materials towards U^{VI} ions, as well as taking advantage of the nature of these MOFs to design photo-switched behaviour for photo-triggered storage/release of U^{VI} ions are at present urgent problems and great challenges to be solved. Herein, we show a simple and facile method to target the goal. Through coordination-based post-synthetic strategy, microporous-mesoporous Zn-MOF-74 was easily functionalized by grafting coumarin on coordinatively unsaturated Zn(II) centers, yielding a series of coumarin-modified Zn-MOF-74 materials. The obtained samples displayed ultra-high adsorption capacity for U^{VI} ions from water at pH value of 4 with maximum adsorption capacities as high as 360 mg/g (the record value in MOFs) and a remarkable photo-switched capability of 50 mg/g at pH value of 4. To the best of knowledge, and in contrast to the well-known photo-switched behaviour towards CO_2 , dye (propidium iodide), as well as fluorescence observed in MOFs, this is the first study that shows a photo-switched behaviour towards radioactive U^{VI} ions in aqueous solution.

Keywords: MOF; U^{VI} uptake; Photo-switching behaviour; Coumarin; Hybrid material

1. Introduction

As predicated by the International Atomic Energy Agency, nuclear power as a mature technology is now receiving major attentions during this century. This is mainly because of the rapidly growing energy demand and concerns regarding climate change due to carbon sources, as well as the decommissioning of more than 400 reactors around the world, built between 1970-1980.¹ Corresponding to this increasing demand, one serious concern about potential risks from radiation sources is the toxic waste generated into the environment, natural water resources, and its effect on human health.²⁻³ Typically, U^{VI} uranium are the major source of nuclear power, thus high-performance and safe storage/release of uranium are of urgent need, great scientific and practical significance, not only in removal of uranium-containing waste for protection of both human health and ecological security, but also in reutilization of uranium resources for sustainable development of nuclear energy.

For this purpose, many efforts, including liquid-liquid extraction,⁴ ion-exchange/absorption,⁵ adsorption,⁶ and chemical/biochemical reductive precipitation,⁷ have been devoted. Among these methods, the most common method in the industry currently to extract U(VI) from aqueous solutions is solvent extraction such as tributylphosphines and tertiary amines,⁸⁻⁹ due to its unique merit such as low cost, fast speed, high efficiency, easy to automatic control, and repeated operation. But this is somewhat restricted in practice by the thermostability of extractant. On the other hand, porous sorbent based adsorption approach is one of the most convenient methods for U^{VI} treatment. First the category of sorbents covers a large range of materials that included activated carbon,¹⁰ activated carbon-silica aerogel composite materials,¹¹ barium titanate,¹² galloxyaniline grafted hydro-gel,¹³ ion-imprinted polymers,¹⁴ polyphenolic compounds,¹⁵ as well as recently developed layered sulfide¹⁶⁻¹⁷ and metal-organic frameworks (MOFs)¹⁸⁻²⁰. Secondly the operation to carry out uranium adsorption/release, based on porous sorbents, is often facile. Among them, MOFs, as a renovated porous platform, has only recently been developed for such purposes. Especially, numerous unique merits such as high BET, uniform pore, functionalized pore wall, and structural

diversity make this material more attractive. Moderate chemostability and thermostability of the MOF skeleton in conjunction with their preferred chemical adsorption towards U^{VI} ions largely benefit the applications in storage and release of uranium in practice. Nevertheless, one serious concern that should be noticed is that the low-cost material available at present in this category is still scarce. Also, seeking for general approach to enhance U^{VI} adsorption capability of MOFs, especially simple MOFs, is of urgent need but still remains a big challenge. Moreover, attempts of exploiting some photo-sensitive MOFs for photo-switched storage and release of U^{VI} are also special of interest in the green storage/release of U^{VI} .

MOF-74 material is one of the most economical MOFs (such as Zn-MOF-74, cost < 2 \$/kg),²¹ showing a robust framework, oxygen-rich interior pore, and potential coordination-unsaturated sites, is now extensively applied in many research fields like magnetism, catalysis, separation, batteries, pharmaceuticals, and so on.²² The facile preparation of microporous-mesoporous presented by Yue and co-workers is one that deserves merit.²³ In this work, as described in Scheme 1, the adsorption of U^{VI} ions on crystal samples of Zn-MOF-74 (A-1), its microporous-mesoporous samples (A-2), and its coumarin loading samples (A-3), was systematically studied. The motive of this research is focused on how to enhance the U^{VI} adsorption capability upon MOFs materials, and construct photo-sensitive MOFs for photo-switched storage/release of U^{VI} .

Scheme 1. The materials used in this work for adsorption and photo-switching storage/release of U^{VI} ions.

2. Experimental detail

2.1 Synthesis.

2.1.1 Microporous Zn-MOF-74. A DMF/isopropanol/ H_2O (2:0.1:0.1, volume ratio) of $Zn(NO_3)_2 \cdot 6H_2O$ (0.1 mmol), 2,5-dihydroxy-1,4-benzenedicarboxylic acid (0.05 mmol) was sealed in a Teflon reactor, heated at $110^\circ C$ for 3 days, and cooled to room temperature at $3^\circ C/h$. Subsequently, block crystals were yielded and dried naturally in air for three days to obtain a product with 85% yield based on Zn. The resulted crystals were washed first with 20 mL of DMF and then 20 mL of methanol. The solid was kept immersed in methanol for 3 days with fresh solvent changed for the same amount and repeated three times. They were then degassed in Belsorp-max under vacuum at $180^\circ C$ for 24h. Element analysis for the activated samples (71% yield based on Zn): calc. C/29.57, H/0.62; exp. C/29.16, H/0.66.

2.1.2 Microporous-mesoporous Zn-MOF-74. The clear solution of $Zn(CH_3COO)_2 \cdot 2H_2O$ (0.343g) in 20 mL DMF was added dropwise to the clear solution of 2,5-dihydroxy-1,4-benzenedicarboxylic acid (0.099g) in 20 mL DMF, immediately leading to a precipitate. Then this was further stirred for 15 min, and the solid was recovered by centrifugation and washed first with 20 mL of DMF and then 20 mL of methanol. The solid was kept immersed in methanol for 3 days with fresh solvent changed for the same amount and repeated three times. They were then degassed in Belsorp-max under vacuum at $200^\circ C$ for 24h. Element analysis for the activated samples (76% yield based on Zn): calc. C/29.57, H/0.62; exp. C/29.79, H/0.53.

2.1.3 Coumarin-modified microporous-mesoporous Zn-MOF-74. 0.5 g activated microporous-mesoporous Zn-MOF-74 was suspended in a solution containing 20ml of n-hexane and 0.07 g (12 wt%)/or 0.11 g (22 wt%)/ or 0.22 g (30 wt%)/ or 0.30 g (37 wt%) of coumarin under stirring at ambient temperature for 15min. n-Hexane was evaporated by a rotary evaporator at 333 K for 2 h,

1 and the resulting material was washed by ethanol (30 mL) three times and then dried under vacuum
2 at 373 K for 24 h.
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4 **2.2 Materials and General Methods.** Reagents and solvents were commercially available (Alfa)
5 and were used without further purification. Thermogravimetric analysis (TGA) was performed by a
6 TGA Q500 thermal analysis system. Data were analyzed using the TA Universal Analysis software
7 package. X-ray powder diffraction were collected by a Bruker AXS D8 Discover powder
8 diffractometer at 40 kV, 40 mA for Cu K α , ($\lambda = 1.5406\text{\AA}$). The simulated powder patterns were
9 calculated by Mercury 1.4. The purity of the bulk products were determined by comparison of the
10 simulated and experimental PXRD patterns. Infrared Spectra (IR) were measured by a Bruker
11 VERTEX 70 spectrometer in the 500-4000 cm^{-1} region. The gas sorption isotherms were collected
12 on a Belsorp-max. Ultrahigh-purity-grade (>99.999%) N₂, CO₂ gases were used during the
13 adsorption measurement. To maintain the experimental temperatures, liquid nitrogen (77 K) and
14 temperature-programmed water bath (298 K) were used respectively. SEM and EDS measurements
15 were carried out using a Hitachi S-4800 microscope.
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18 **2.3 Uranium Uptake Experiments.** The uranium uptake was carried out *via* a batch
19 method. For example, uptake experiments were performed at controlled pH values of 1-7
20 and 298K by adding 10mg MOF material to 10 mL of a uranyl solution in a 50 mL
21 high-density Polymer polypropylene tube (previously cleaned with 5% HNO₃ and rinsed
22 three times with ultrapure water). The solution pH was adjusted to the desired value of 1-7
23 by HCl (1M)/NH₃H₂O(1:1) and determined by pH meter. After shaking for a predesigned
24 time (0-5 h) with fixed temperature in the ZWY-240 in a constant shaking incubator, the
25 suspension was centrifuged at 10,000 rpm for 10 min, then the sorbent was separated by
26 centrifugation and the rest solution is analyzed for U concentration by a spectrophotometer
27 (TU-1901), and further confirmed by inductively coupled plasma-mass spectroscopy
28 (ICP-MS, NexION 300X). Arsenazo III dye was used as the color-developing agent for U,
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giving an intense absorption band at 650 nm. Before the determination, the solution was diluted 2.5-100 times to make sure that the finally uranium concentration meets the standard curve in the range of 0.1-3 mg/L.

3. Results and discussion

The crystal samples **A-1** was synthesized by the reaction of 2,5-dihydroxy-1,4-benzenedicarboxylic acid and $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ in the ratio of 2:1 in mixed solvents of DMF/isopropanol/ H_2O (2:0.1:0.1, volume ratio). The structure was determined by single crystal X-ray diffraction and agrees well with literature reports.²² The phase purity of the bulk samples were confirmed by powder X-ray diffraction (PXRD, Figure 1). According to the synthesis method in the literature,²³ **A-2** is synthesized by stirring 2,5-dihydroxy-1,4-benzenedicarboxylic acid and $\text{Zn}(\text{CH}_3\text{COO})_2 \cdot 2\text{H}_2\text{O}$ in DMF for 15 min at room temperature. The phase purity of **A-2** was further confirmed by PXRD through comparing PXRD patterns of **A-2** with PXRD patterns of **A-1**. The preparation of **A-3** was also referred to the literature method by loading coumarin in activated **A-2**.²⁴ The comparison of PXRD patterns between **A-2** and its coumarin-modified phase **A-3** suggests that the special MOF skeleton of Zn-MOF-74 was well maintained even after loading coumarin inside it.

Figure 1. PXRD patterns simulated from single crystal data of Zn-MOF-74, and PXRD patterns of samples **A-1**, **A-2**, and **A-3** series with different loads of coumarin.

Figure 2. a), c) N₂ adsorption/desorption isotherms at 77K of **A-1**, **A-2**, and **A-3** series; b), d) their corresponding pore size distributions (PSDs) calculated by NLDFT. Note that, for example, ‘**A-3:11.7wt%**’ means that in this sample about 11.7 wt% coumarin was loaded inside **A-3**, while ‘**A-3:11.7wt%** under UV’ means that before carrying out N₂ adsorption experiment the **A-3:11.7wt%** sample were irradiated under UV (320 nm) for 30 min.

As shown in Figure 2, the aperture of samples **A-1** estimated by N₂ adsorption at 77K, is ca. 0.79 nm, which is consistent with the value reported in the literature.²² In contrast to the type-I isotherm for microporous samples **A-1**, the N₂ adsorption-desorption isotherm of samples **A-2** displays type-IV isotherms with hysteresis loops characteristic of large constricted mesopores. The pore-size distribution (PSD), calculated by nonlocal density functional theory (NLDFT) suggests these are microporous-mesoporous materials with the distributions of a micropore around 0.84 nm

and a mesopore width as large as of 9 nm. This is comparable with that reported recently by Yue *et al.*,²³ as for similar structures, the **A-3** series, the micropores were found to gradually disappear along with increasing loading amount of coumarin (for example, more than 20.6wt%). Correspondingly, the widepore size distribution observed in samples **A-2** becomes narrow in pore size distribution in the **A-3** series. These results, combined with the very low CO₂ adsorption in **A-3**: **11.7wt%**, strongly suggests that both micropores and mesopores were modified by coumarin.

The loading amount of coumarin is estimated by both EA (element analysis) and thermogravimetric analyses (TG). The results in detail are listed in Table S1 and Figure S1. And the **A-3** series were named as **A-3: 11.7wt%**, **A-3: 20.6wt%**, **A-3: 28.2wt%**, **A-3: 35.7wt%**, respectively, where for example “11.7wt%” means that the loading amount of coumarin on MOF material is about 11.7wt%. The amount of CO₂ adsorption at 298 K and 100 kPa is 120.2 cm³/g for **A-2**, typical of CO₂ adsorption capability for Zn-MOF-74 showing open Zn(II) site (Figure S7). However, this is sharply reduced to 12.1 cm³/g for **A-2** after loading 11.7 wt% coumarin, which is likely the results of the prior occupation of coumarin oxygen atom on the open Zn(II) site (Figure S2).

The ultraviolet (UV) diffuse reflectance spectrum of coumarin-modified samples (**A-3** series) is shown in Figure S3. In comparison to samples **A-2**, new peak is observed in **A-3** series around 313 nm, characteristic of absorption band for coumarin.²⁴ Irradiation of sample **A-3** series with UV light for 1 min with wavelengths of 320 nm results in sharp increase in the absorption band around 270 nm, indicative of occurrence of photodimerization inside **A-3** series.²⁴ This can be further reflected in the N₂ adsorption (Figure 2) and TG tests (Figure S4). For example, the amount of N₂ adsorption at P/P0=1 is 516.7 cm³/g, whereas after UV (320 nm) irradiation for 30 minutes this decreases to 302.2 cm³/g, giving a difference of 41.5% in reduction. However, along with increasing the loading of coumarin, similar trends were also observed but with less alteration (for example, a photo-switching

alteration of 34.3% was observed for **A-3** after loading 35.7 wt% coumarin). This strongly suggests that the formation of a more dense phase along with increasing the loading of coumarin occurred. Accordingly, we can find that such “open-close double doors” system in **A-3** after loading coumarin of less than 20.6 wt% has little effect on sealing guest molecules. Moreover, the thermostability of **A-3** series with or without UV was investigated. Figure S5 presented the observation of alteration for the weight loss before 114°C (losing guest molecules) in **A-3** series materials with or without UV irradiation. Notably, only samples **A-3: 28.2%** and **A-3: 35.7%** displayed big difference. For instance, **A-3: 28.2wt%** losses its guest molecule of 22.1% before 114°C, whereas it after UV irradiation only give a weight loss of 6.9%, giving a large change of 68.7% and suggesting an effective seal of guest. Even more, a change of 72.5% is observed for **A-3: 35.7wt%** with/without UV irradiation. This agrees with that in this situation such “open-close double doors” system can excellently seal guest molecules. Moreover, to exclude that such photo-switching behaviour may result from the structural transformation after photodimerization inside **A-3** series, the comparison of PXRD patterns between **A-3** series and that after UV irradiation was carried out, where the PXRD patterns between them could be well matched, thus strongly suggesting unchanged skeleton between them (Figure S5) and that these MOF materials did not suffer radiation damage from the UV exposure.

To evaluate the ability of **A-1**, **A-2**, and **A-3** series to adsorb U^{VI} ions, batch experiments were carried out. As shown in Figure 3 and Figure S6-11, the adsorption capability of **A-1** was 190 mg/g at pH=4 and room temperature. Note that most often uranium containing solutions in the industry are often much more acidic with pH~1, and the optimal pH of 4 in this work is much higher than often found in the industry, thus, in practice this would cause the precipitation of other ions in solution such as Fe or Al phases.²⁵⁻²⁶

The kinetics of adsorption can be well fitted by the pseudo-second-order rate equation (Figure S7), implying a dominating chemical adsorption rather than physical adsorption. The sorption isotherms observed in this work, according to the Langmuir model (Figure S8), indicate that the adsorption of U^{VI} ions is localized in a monolayer.²⁰⁻²² A similar situation is observed in **A-2**, but the adsorption capability of it is largely enhanced up to 300 mg/g. This should benefit from the microporous-mesoporous form in **A-2**, relative to the microporous form in **A-1**. Notably, the adsorption capability can be further enhanced *via* loading of coumarin inside of **A-2**. For instance, the material of loading 11.7 wt% coumarin inside of **A-2** could generate adsorption capability as high as of 360 mg/g. This largely exceeds the best values in MOFs such as UiO-68-P(O)(OEt)₂ (217 mg/g)¹⁸ and MOF-76 (298 mg/g),¹⁹ and is of comparable with the best documented U^{VI} sorbents (307-380 mg/g) like that of KMS-1 (382 mg/g),¹⁶ S_x-LDH (x=2, 4, 330 mg/g),¹⁷ and functionalized hydrothermal carbon (HTC) (307 mg/g)¹⁵. However, continuing to increase the amount of coumarin inside of **A-2** results in the decrease of U^{VI} adsorption capability, as observed in **A-3: 20.6wt%** (356 mg/g), **A-3: 28.2wt%** (350 mg/g), and **A-3: 35.7wt%** (280 mg/g), as in this situation, although increasing the amount of coumarin created more chance to chemically adsorb U^{VI} ions, however, the finally U^{VI} adsorption capability is seriously restricted by the gradual decrease of effective pore like observed in Figure 2c. **The small variety in U^{VI} adsorption capacity between **A-3: 20.6wt%** and **A-3: 28.2wt%** is mainly due to that such increase of coumarin on MOF material that would create more chemical adsorption sites for U^{VI} ions could compensate the decrease of effective pore (due to the increase of coumarin on MOF material) that would reduce U^{VI} adsorption capacity. By contrast, when loading of 35.7wt% coumarin on MOF materials would largely reduce the effective pore for U^{VI} adsorption, although more chemical adsorption sites for U^{VI} ions are created after loading of more coumarin on MOF materials. And in this situation, the balance is largely destroyed, thus**

generating a bigger variety in U^{VI} adsorption capacity between **A-3: 20.6wt%** and **A-3: 35.7wt%**.

Figure 3. Adsorption isotherms of uranium ion on porous materials used in this work. $m_{\text{adsorbent}}=10$ mg, pH=4, t=5 h and T=298 K.

The photo-switching performance towards U^{VI} ions in aqueous solution was also explored. Note that samples **A-3: 11.7wt%** does not show any photo-switching behavior towards UO_2^{2+} , as evidenced by the adsorption capability of it under ambience or after UV irradiation showing almost no detectable alteration. In contrast, such behavior prevailed in **A-3: 20.6wt%**, **A-3: 28.2wt%**, and **A-3: 35.7wt%**, resulting in difference (8.7%, 14.3% and 12.3%, respectively) in U^{VI} adsorption capacity with/without UV (Figure 4). Interestingly, this can be well recovered with the efficiency of approximately 100% by reirradiating the same samples under 250 nm, which mainly due to the unique “open-close double doors” system formed by the reversible photodimerization inside **A-3** series. In addition, such photo-switching storage and release of U^{VI} ions can be further reflected in the eluted experiments. The adsorbed U^{VI} ions in **A-3: 28.2wt%** can be easily eluted by 0.1 M HCl with elution efficiency of 80%, whereas identical samples after UV irradiation (320 nm), under the same eluting conditions, give only a 60% elution efficiency, indicative of 20% U^{VI} ions (equal to 70

mg/g) that were sealed inside sorbent by means of such photo-switching technique. Similarly, reirradiating the same samples under 250 nm completely rereleases the sealed 20% U^{VI} ions (Figure 5).

Seen from the above experimental results, it is clear that the U^{VI} adsorption capability of microporous Zn-MOF-74 (**A-1**) is largely enhanced by 58% when it is prepared as microporous-mesoporous material (**A-2**), and this is further magnified by 20% when it is modified by coumarin, resulting in an overall U^{VI} adsorption capability of 360 mg/g. Moreover, the coumarin-modified microporous-mesoporous Zn-MOF-74 (**A-3**) triggered by UV facilitates to generate an “open-close double door” system in the pore outlets,²⁴ which consequently allows for reversible photocontrol over U^{VI} ions entering into porous materials. This best photo-switching efficiency is estimated to be 14.3% (50 mg/g).

As discussed above, relatively speaking, in this study samples **A-3: 28.2wt%** showing high U^{VI} adsorption capability of 350 mg/g and smart photo-switching storage and release of U^{VI} in aqueous solution seems more suitable for U^{VI} adsorption. Thus, the U^{VI} adsorption and stability of it was also confirmed by IR (Infrared Spectrum), TG, PXRD, SEM (Scanning Electron Microscopy) and EDS (Energy Dispersive Spectroscopy). Among these IR bands, significant variety for C=O bond after loading of U^{VI} ions on MOFs such as appearance of new peak at 1506 cm^{-1} and disappearance of peak at 1548 cm^{-1} strongly suggests the interactions between C=O groups of coumarin and U^{VI} ions.²⁷⁻²⁸ Moreover, the appearance of new peaks of 918 cm^{-1} in samples **A-3: 28.2wt%** after loaded U^{VI} ions (namely **A-3: 28.2 wt% @ UO_2^{2+}**), typical of the characteristic stretching bond of UO_2^{2+} , clearly indicates the adsorption of U^{VI} on **A-3: 28.2wt%**.¹⁹⁻²⁰ While another new peak at 748 cm^{-1} is in agreement with the formation of new U-O bond, which, most likely, attributes to the ester group of coumarin (Figure S12).¹⁹⁻²⁰ Moreover, in the TG plots (Figure S13), the residual weight percentage after 500°C for **A-3: 28.2wt% @ UO_2^{2+}** is 2.7 times bigger than that observed in **A-3: 28.2wt%**, which is ascribed to the loading of U^{VI} on **A-3: 28.2wt%** that will generate heavier

uranium compounds after calcinations. Furthermore, as evidenced by PXRD investigations, the PXRD patterns of **A-3: 28.2wt%** approximately match that of its U^{VI} -loaded phase, indicative of that the MOF-74 skeleton can be well maintained in **A-3: 28.2 wt%@ UO_2^{2+}** (Figure S14). Furthermore, the uptake of U^{VI} on **A-3: 28.2 wt%** is detected by SEM and EDS analyses (Figure S15, S16). The almost disappear of pore structure in **A-3: 28.2 wt%@ UO_2^{2+}** strongly confirms the loading of U^{VI} (Figure S10). The content estimated by EDS is 1:1 for U:Zn, in accordance with the experimental adsorption capability of 350 mg/g.

Figure 4. The adsorption isotherms of uranium ion on porous materials under ambience or after UV (320 nm) irradiation. $m_{\text{adsorbent}}=10$ mg, $pH=4$, $t=5$ h and $T=298$ K, $t_{\text{irradiation}}=30$ min.

Figure 5. Various elution efficiencies under different eluting conditions for samples A-3: 28.2 wt% after fully loading UO_2^{2+} . Note: the elution colored in yellow is the samples after UV (320 nm) irradiation for 30 min and that was eluted by 0.1M HCl. The elution colored in black represented reirradiating above samples under UV (250 nm) for 30 min and then eluting by 0.1M HCl.

4. Conclusions

In summary, we demonstrated here how not only to enhance the U^{VI} adsorption capability of MOF materials, but also how to access photo-switching storage and release of U^{VI} , using simple and economic MOF materials. Selecting Zn-MOF-74, we found that such material in the microporous-mesoporous form could largely enhance the U^{VI} adsorption capability by 58%, then doping coumarin inside this material further improved the adsorption performance by 20%. Therefore our work showed an innovatory, simple, and effective pathway to prepare MOF or hybrid MOF materials with high U^{VI} adsorption capability. Moreover, based on the reversible photodimerization between two coumarin molecules, the construction of a smart “open-close double door” system on the outlet of MOF materials creates a 14.3% photo-switching capability for storage/release of U^{VI} in aqueous solution at pH=4. Therefore our work here opens up a unique method for green storage/release of U^{VI} in aqueous solution. Furthermore, it is known that established photo-switching behavior towards CO_2 , dye, and fluorescence in MOFs is mainly

1 derived from *trans-to-cis* transformation of azobenzene units or *open-ring-to-close-ring*
2 transformation of diarylethene unit.²⁹⁻³¹ By contrast, our work has opened up a gate to access
3 photo-switching behavior towards radioactive U^{VI} ion, by means of reversible photodimerization of
4 coumarin molecules.
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