

## Electronic Supplementary Information

# A novel luminescence probe based on layered double hydroxides loaded with quantum dots for simultaneous detection of heavy metal ions in water

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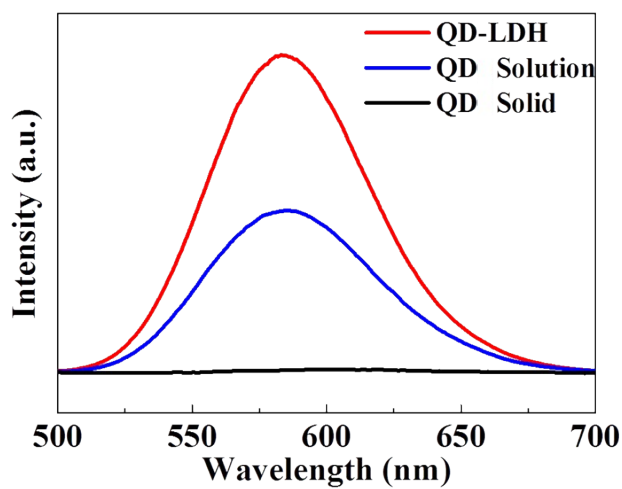
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## Table S1.

**Table S1.** Data summary for the detection and analysis of different ions using the luminescence sensor.  $c$  is the concentration of metal ions and  $I$  is the luminescence intensity.

Ions	Range (mM)	Linear equation	Linear correlation coefficient ( $R^2$ )	The limit of detection (mM)
$Pb^{2+}$	0 ~ 10	$I=290.7+1810e^{-1.122c}$	0.9751	$1.3 \times 10^{-4}$
	0 ~ 1	$I=2148-1395c$	0.9854	
$Cr^{3+}$	0 ~ 10	$I=333.2+1826e^{-0.6854c}$	0.9725	$4.5 \times 10^{-4}$
	0 ~ 1	$I=2149-1196c$	0.9853	
$Hg^{2+}$	0 ~ 10	$I=375.4+1751e^{-0.6738c}$	0.9607	$6.8 \times 10^{-4}$
	0 ~ 1	$I=2142-1094c$	0.9788	
Mixed ions	0 ~ 10	$I=352.2+1778e^{-1.025c}$	0.9538	$9.3 \times 10^{-4}$
	0 ~ 1	$I=2137-1133c$	0.9527	

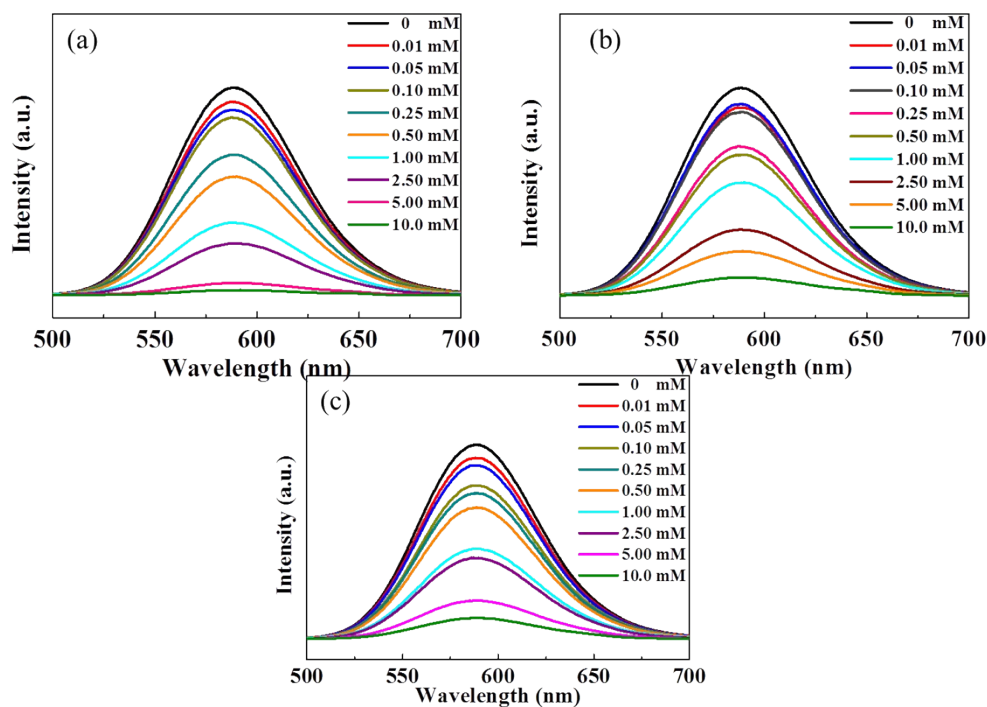
**Figure. S1**



**Fig. S1.** Luminescence spectra of different systems including the QD-LDH composite, QD dispersion, and QD solid.

It's well acknowledged that the QDs, without being dispersed in water, are easy to aggregate and result in luminescence quenching. To overcome the problem and achieve superior performance, the QDs and LDH were combined together to obtain a composite material with high luminescence intensity, which was not affected by drying process (Fig. S1).

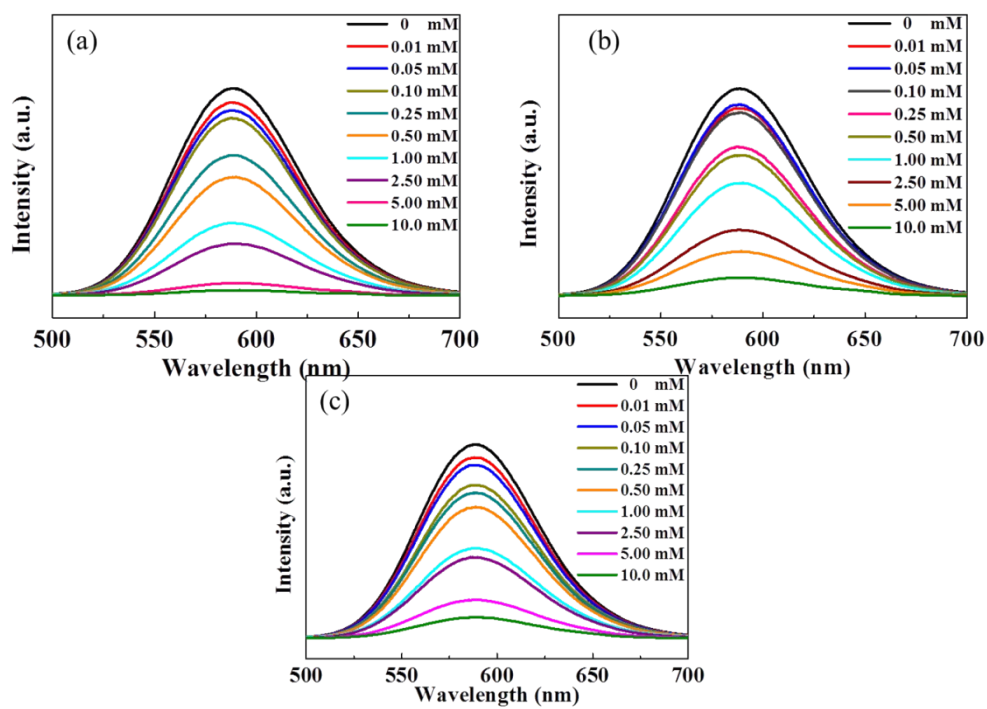
**Figure. S2**



**Fig. S2.** Luminescence spectra of the QD-LDH in the presence of different concentrations of  $\text{Pb}^{2+}$  (a),  $\text{Cr}^{3+}$  (b), and  $\text{Hg}^{2+}$  (c).

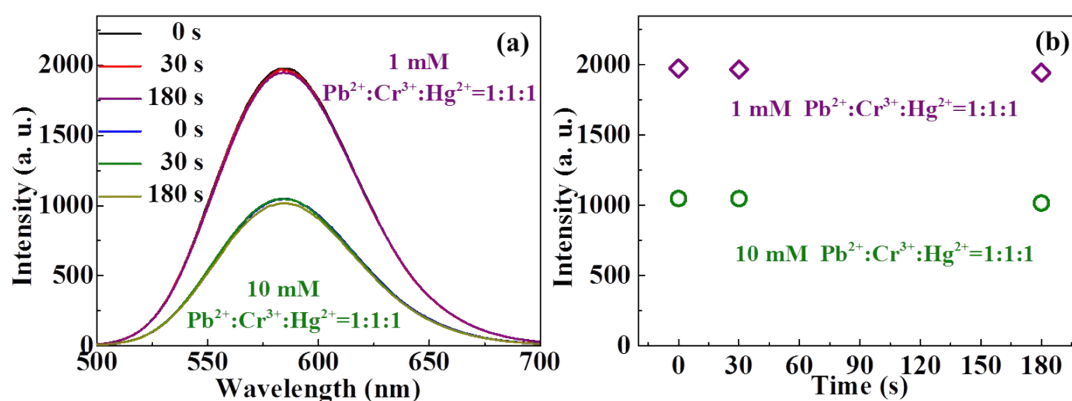
To find out the relationship between the concentrations of  $\text{Pb}^{2+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Hg}^{2+}$  and luminescence intensity, a series of experiments was carried out. It was obvious that the intensity decreased systematically with increasing concentrations of each metal ion, proving the potential use of the composite as a sensor for detecting multiple heavy metal ions in aqueous solution.

**Figure. S3**



**Fig. S3.** Luminescence spectra of the QD-LDH in the presence of different concentrations of  $Pb^{2+}$  (a),  $Cr^{3+}$  (b), and  $Hg^{2+}$  (c).

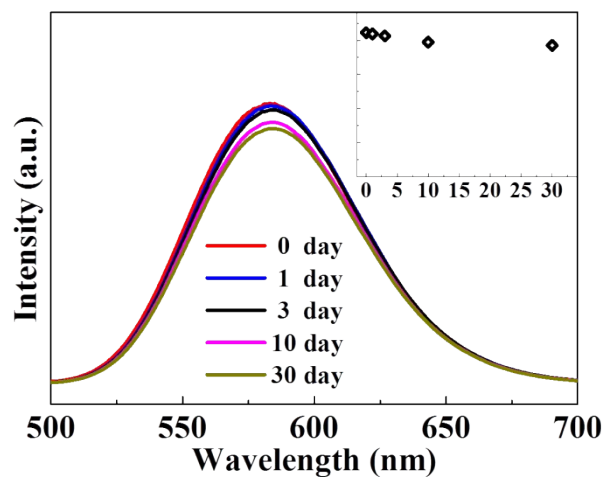
**Figure. S4**



**Fig. S4.** Luminescence spectra (a) and intensity (b) of the QD-LDH composite measured after different time when the solution with heavy metal ions dropped onto the powder.

The detection speed was fast by using the QD-LDH composite. The luminescence intensity was measured of different delay time when the solution with heavy metal ions was dropped onto the powder. It's obvious there was almost no change in the luminescence intensity with a longer time delay. Therefore, this novel QD-LDH composite material showed a great potential to be used for fast and on-site detection of  $\text{Pb}^{2+}$ ,  $\text{Cr}^{3+}$ , and  $\text{Hg}^{2+}$  in real water.

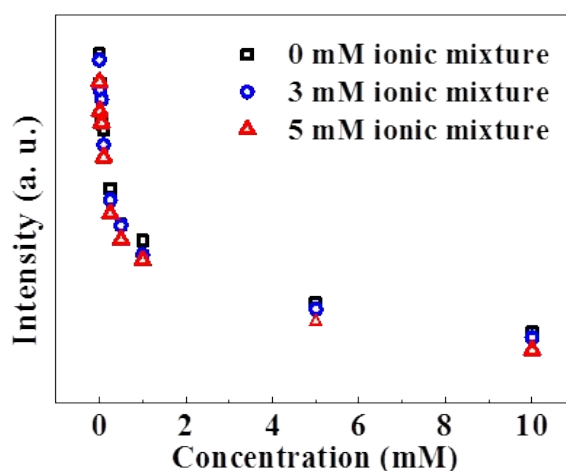
**Figure. S5**



**Fig. S5.** Luminescence spectra of the QD-LDH composite after stored in room temperature for different days.

The QD-LDH composite showed excellent time stability, as seen in Fig. S4. There was only a slight decrease of the luminescence intensity on the thirtieth day after compositing process. Thus, it can be demonstrated that the QD-LDH composite has the ability to be applied in the field of luminescence sensor.

**Figure. S6**

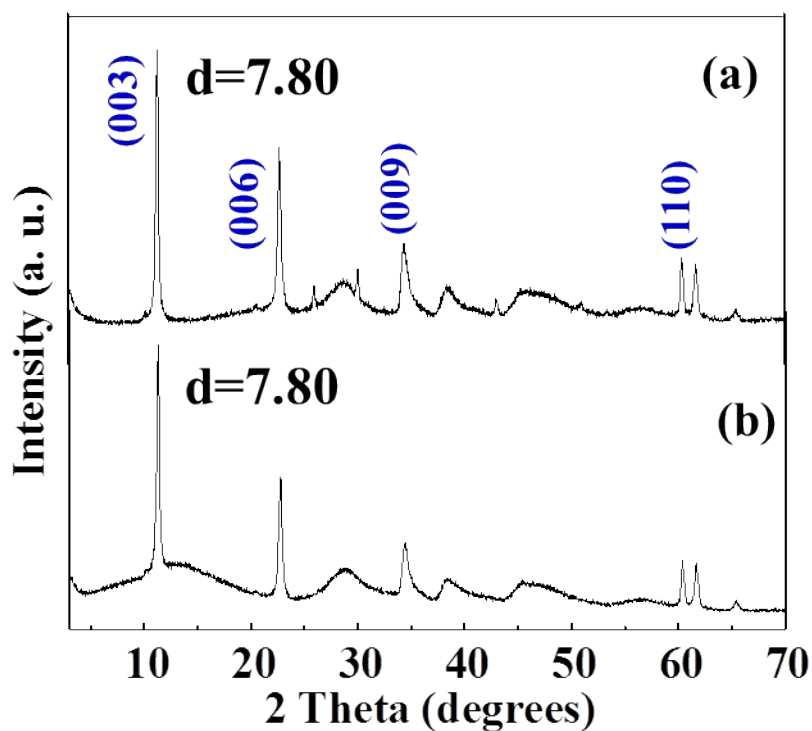


**Fig. S6.** Luminescence intensity of QD-LDH in the presence of different total concentration of  $\text{Pb}^{2+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Hg}^{2+}$  ( $\text{Pb}^{2+}:\text{Cr}^{3+}:\text{Hg}^{2+}=1:1:1$ ) in 0, 3, 5 mM ionic mixture solution.

The interference test was carried out by the method reported in the literature with minor modifications. The heavy metal ions detected by QD-LDH was investigated in the presence of some other metals made of  $\text{Mg}^{2+}$ ,  $\text{Al}^{3+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Cl}^-$ ,  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$  as well. The ratio of  $\text{Pb}^{2+}:\text{Cr}^{3+}:\text{Hg}^{2+}$  was 1:1:1. It could be inferred that the detection was sensitive in the presence of a relatively high concentration of ionic mixtures. In the presence of an ionic mixture containing 5 mM of these ions, the QDs were able to detect mixed  $\text{Pb}^{2+}$ ,  $\text{Cr}^{3+}$ , and  $\text{Hg}^{2+}$  without evident interference. Therefore, this novel QD-LDH composite material shows a great potential to be used for simultaneous detection of  $\text{Pb}^{2+}$ ,  $\text{Cr}^{3+}$  and  $\text{Hg}^{2+}$  in real water.



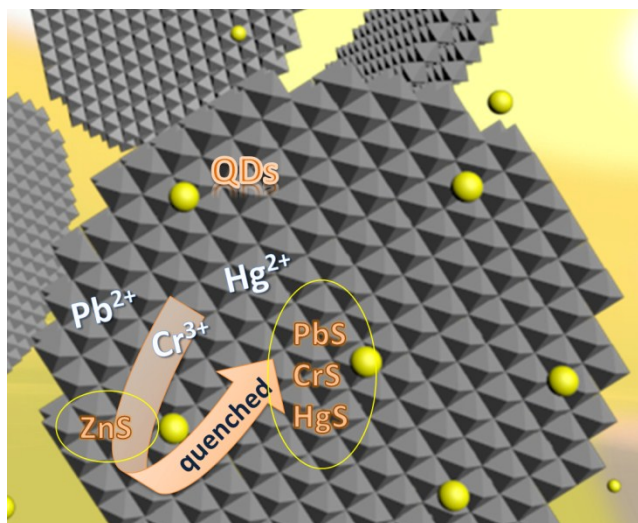
**Figure. S7**



**Fig. S7.** X-ray diffraction patterns of QD-LDH after (a) and before (b) detecting heavy metals.

The first peak of QD-LDH was not moved nor broadened after metal adsorption, suggesting no change of the interlayer space. The layer spacings were 0.78 nm which were not changed as well. The conclusions of XRD experiments inferred that the LDH intercalated by carbonate was stable to some extent.

**Figure. S8**



**Fig. S8.** The mechanism diagrams of the ZnS quantum dots quenching when contacted with heavy metal ions.

The metals, which have lower  $K_{sp}$  values with the corresponding chalcogenide, can displace the QD cations via cation-exchange. The surface of the QDs is susceptible to a potential cation exchange reaction, leading to luminescence quenching.