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H_2O_2-sensitive quantum dots for the label-free detection of glucose

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ABSTRACT

A novel label-free detection system based on CdTe/CdS quantum dots (QDs) was designed for the direct measurement of glucose. Herein we demonstrated that the photoluminescence (PL) of CdTe/CdS QDs was sensitive to hydrogen peroxide (H_2O_2). With D-glucose as a substrate, H_2O_2 that intensively quenched the QDs PL can be produced *via* the catalysis of glucose oxidase (GOx). Experimental results showed that the decrease of the QDs PL was proportional to the concentration of glucose within the range of 1.8 μM to 1 mM with the detection limit of 1.8 μM under the optimized experimental conditions. In addition, the QD-based label-free glucose sensing platform was adapted to 96-well plates for fluorescent assay, enhancing the capabilities and conveniences of this detection platform. An excellent response to the concentrations of glucose was found within the range of 2–30 mM. Glucose in blood and urine samples was effectively detected *via* this strategy. The comparison with commercialized glucose meter indicated that this proposed glucose assay system is not only simple, sensitive, but also reliable and suitable for practical application. The high sensitivity, versatility, portability, high-throughput and low cost of this glucose sensor implied its potential in point-of-care clinical diagnose of diabetes and other fields.

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1. Introduction

Glucose detection plays an important role from several points of view ranging from life science [1], biology [2–4], clinical analysis [5], the food industry [6] and so forth. Since the glucose sensor was first proposed in 1962 [7], a great deal of effort has been focused on fabricating smart sensors for precisely monitoring the glucose level with high sensitivity, high reliability, fast response, good selectivity, and low cost. Among these techniques, the electrochemical biosensors were the most prominent and remained to be popular used [8,9]. However, while the advantages of electrochemical sensors were obvious, the optical sensors have becoming indispensable considering they are immune to electromagnetic interference, easy to miniaturize, and require low power supply. The fluorescence-based optical detection are extremely sensitive, but the cumbrance of sensor construction is a common bottleneck often mentioned in the literature [10].

Semiconductor quantum dots (QDs) have attracted widespread interests in biology and medicine due to their unique optical and electronic properties. These properties, especially high quantum yield and photostability, and size-dependent tunable photoluminescence (PL) with narrow emission bandwidth and broad excitation, make them desirable fluorescent tags for evaluating biomolecular signature in vitro and in vivo [11–15]. Many reports have proved that the QDs could be responsive to external stimuli or to the molecular composition of environment. Based on this novel feature, the QDs have been utilized for construction of sensors for detecting specific analytes, such as pH [16,17], metal ions [18–20], organic compounds [21,22], and biomolecules [23,24]. Particularly, the interactions between QDs and redox-active molecules have been investigated in the context of biosensing [25–27].

The fluorescent QDs were first employed for glucose sensing by Singaram's group [28]. The PL of the QDs can be quenched through the complex formation with boronic acid-substituted viologen quenchers. The binding of glucose with the boronic acid-substituted quencher broke the quencher–QD interactions and induced a robust fluorescence recovery. Zhou and co-workers [29] reported a glucose sensing system based on the immobilization of fluorescence QDs in the interior of boronic acid-based microgels for continuous optical detection of glucose. Willner and co-workers [30] constructed a glucose sensor through conjugating H_2O_2-sensitive QDs with glucose oxidase (GOx). GOx catalyzed the oxidation of D-glucose and hydrogen peroxide (H_2O_2) was produced, resulting in the quenching of the QDs PL. However, these systems required complicated modifications of both QDs and quenchers, or suffered from laborious labeling processes that may interfere with the function of QDs and enzyme. The tedious process and high sample consumption limited their practical application.

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Hence, development of a label-free and portable glucose detection method would attract more interests and have extensive applications. Herein, we describe a simple scheme of construction of a glucose sensing platform, which is composed of H_2O_2-sensitive QDs and GOx, without any complex processes of functionalization or conjugation. The sensing mechanism is based on the fluorescence quenching of the QDs by H_2O_2 that produced from enzymatic reaction of glucose. This label-free assay provides a simple, economical avenue for detection of glucose with high sensitivity. The detection carried out in 96-well plates facilitates and visualizes the procedure, and indicates its potential to be a portable and miniature blood sugar detector.

2. Experimental

2.1. Chemicals and materials

All chemicals were of reagent grade and used as received from the manufacturers. Tellurium powder (99.9%), $CdCl_2$ (99.9%), bovine serum albumin (BSA), and other chemical reagents were purchased from Sigma–Aldrich (St. Louis, MO, USA). 3-Mercaptopropionic acid (MPA) (98%) was purchased from Fluka. NaH_2PO_4, Na_2HPO_4, H_2O_2, D-glucose, L-glucose, GOx and L-ascorbic acid were purchased from Shanghai Sangon Biotechnology Co. Ltd. (Shanghai, China). Uric acid was obtained from Wako Chemical (Tokyo, Japan). Artificial urine was purchased from Biopanda Diagnostics (United Kingdom).

2.2. Synthesis of water-dispersed CdTe/CdS QDs

2.2.1. Preparation of CdTe core QDs

Nearly monodisperse CdTe core QDs were obtained *via* microwave irradiation as described previously [31]. Briefly, the CdTe precursor solution was prepared by adding freshly prepared NaHTe solution to a N_2-saturated $CdCl_2$ solution at pH 8.4 in the presence of MPA as stabilizer. The precursor concentrations were $[Cd^{2+}] = 1.25$ mM, [MPA] = 3.0 mM, $[HTe^-] = 0.625$ mM, respectively. An amount of 50 mL of CdTe precursor solution was injected into the exclusive vitreous vessel, which is a glass tube used especially for microwave instrument. CdTe QDs with the maximum emission wavelength of around 520 nm were prepared under microwave irradiation for 1 min at 100 °C. The CdTe QDs sample was taken when the temperature decreased naturally below 50 °C. The as-prepared CdTe solution was concentrated by 4 times *via* rotary evaporation and was then precipitated with 2-propanol by centrifugation. The colloidal precipitate was redissolved in 3 mL of ultrapure water, acting as CdTe core QDs in subsequent steps.

2.2.2. Preparation of CdTe/CdS core/shell QDs

The CdTe/CdS precursor solution was prepared by adding the as-prepared CdTe core QDs to a N_2-saturated solution with the concentration of 1.25 mM $CdCl_2$, 1.0 mM Na_2S, and 6.0 mM MPA in pH 8.4. An amount of 4 mL of CdTe/CdS precursor solution was injected into the exclusive vitreous vessel. Serial sizes of high-quality CdTe/CdS QDs were achieved on the basis of regulating the reaction time of microwave irradiation. After finishing microwave irradiation, the CdTe/CdS QDs sample was taken when the temperature decreased naturally below 50 °C. The as-prepared CdTe/CdS solution was concentrated by 4 times and was then precipitated with 2-propanol by centrifugation. The colloidal precipitate was redissolved in 3 mL of ultrapure water. The pH of the obtained QDs solution was 6.7. The photoluminescence quantum yield (PLQY) at room temperature was estimated using R6G (QY = 95%), R640 (QY = 100%), or LD690 (QY = 63%) as the fluorescence standards in ethanol, respectively, according to the different maximum emission wavelengths of CdTe/CdS core/shell QDs. The size of the CdTe/CdS QDs was in the range of 3–5 nm *via* high-resolution TEM characterization as described previously [32].

Two kinds of QDs were employed in this experiment: one with the maximum emission wavelength of 535 nm (green-emitting under UV irradiation) and the other with the maximum emission wavelength of 630 nm (red-emitting under UV irradiation). Their PLQY were 48% and 56%, respectively. The as-prepared QDs are very stable in deionized H_2O at 4 °C, no significant changes in the PL were detected during several months. Considering the toxicity of CdTe and CdTe/CdS QDs, undue skin contact should be avoided.

2.3. Fluorescence experiments

All fluorescence spectra were recorded on a luminescence spectrometer (Hitachi F4500, Japan). The emission spectra (400–800 nm range) were recorded under a fixed excitation wavelength of 350 nm at a scan rate of 2 nm/s. The slot widths of the excitation and emission were both 5 nm. For the study of the quenching effect of H_2O_2 on QDs, 10 μL of QDs (10 μM, $\lambda_{em} = 630$ nm) was diluted with 150 mM phosphate buffer (PB, pH 7.5), and a certain volume of H_2O_2 solution was added into the diluted QDs. For the detection of glucose, 100 μL of GOx (20 μg/mL) was mixed with 10 μL of QDs (10 μM), and diluted with 150 mM PB (pH 7.5). Then the glucose solutions with different concentrations were added into the QDs/GOx mixture for fluorescent detection.

2.4. Detection of glucose in 96-well plates

Each well of plate was loaded with 10 μL of QDs (10 μM, $\lambda_{em} = 535$ nm) and 100 μL of GOx (20 μg/mL). Then glucose samples with serial dilutions were added. The QDs PL intensity were measured for a fixed time interval of 10 min using a Tecan GENios fluorometer equipped with an excitation filter (340 nm) and an emission filter (535 nm). The photographs of 96-well plates were captured by Cannon digital camera under ultraviolet (UV) irradiation.

Four standard samples with known glucose concentrations were detected using Accu-Chek Blood Glucose Monitoring Systems (Roche Diagnostics, Germany) and the proposed QD-based assay, and the measured values were compared with the standard values.

2.5. Detection of glucose in blood samples and urine samples

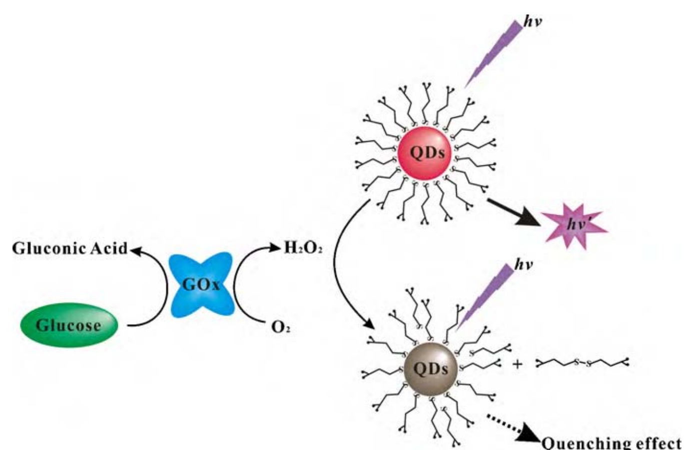
Blood samples were obtained from volunteers in our laboratory. Ten microlitres of QDs (10 μM, blocked with 10% BSA) and 100 μL of GOx (20 μg/mL) was mixed, and 2 μL blood sample was added. The glucose concentration was determined by the calibration curve. Corresponding experiments were carried out with Accu-Chek Blood Glucose Monitoring Systems.

Glucose was dispersed in artificial urine and urine samples with known glucose concentrations were obtained. Ten microlitres of QDs (10 μM, blocked with 10% BSA) and 100 μL of GOx (20 μg/mL) was mixed, and 2 μL urine sample was added. The glucose concentration was determined by the calibration curve. Corresponding experiments were carried out with Accu-Chek Blood Glucose Monitoring Systems.

3. Results and discussion

3.1. Study the quenching effect of H_2O_2 on PL emission of the CdTe/CdS QDs

The MPA-capped CdTe/CdS QDs employed in our experiment possess excellent aqueous dispersibility and fluorescence properties. Post-treatment or phase transfer is not required when detection is carried out in water, PB and biological fluids.



Scheme 1. Schematic illustration of the glucose sensor based on H_2O_2-sensitive QDs. In the presence of GOx, glucose is oxidated, and H_2O_2 is derived from deoxidation of O_2. Based on the quenching effect of H_2O_2 on the QDs, the glucose is detected *via* monitoring the change of the QDs PL.

The basic principle of our QD-based glucose sensor was shown in Scheme 1. The detection was based on the combination of the glucose enzymatic reaction and the quenching effect of H_2O_2 on the QDs PL. To prove the feasibility of our scheme, we firstly investigated the influence of the H_2O_2 on the PL emission of the CdTe/CdS QDs. To this end, we measured the QDs PL as a function of the H_2O_2 concentration. The response of the QDs at increasing H_2O_2 concentration was shown in Fig. 1a. The top line is the original fluorescence spectra of the QDs without any H_2O_2. Upon stepwise addition of H_2O_2, the PL intensity of the QDs gradually decreased. We assumed that, in the presence of H_2O_2, the thiol groups of MPA tagged on the surface of the QDs through Cd–S bonding are readily oxidized to form an organic disulfide product (RS–SR). As a result, more MPA molecules are detached from the surface of the QDs, thus quenching the fluorescence of the QDs [33]. Another quenching mechanism relied on the electron-transfer reaction that occurred at the surface of the QDs where H_2O_2 was reduced to O_2, which in turn lied in electron/hole traps on the QDs and could be used as a good electron acceptor, thus forming the non-fluorescent QDs anion and leading to reduced the fluorescence [34]. Compared with previous reports in which Stern–Volmer analysis gave linear plots [28,35], we observed an uncharacteristic profile in our quenching study (Fig. 1b). The quenching efficiency increased with the increasing H_2O_2 concentration up to 5.0 mM, after which it reached saturation. Such saturation behavior was also observed by several other groups studying the PL quenching of the QDs [36]. Such a profile might indicate the presence of multiple fluorescence pathways, some of which were less efficiently quenched than others, or it was explained by limited accessibility of H_2O_2 to the QDs surface.

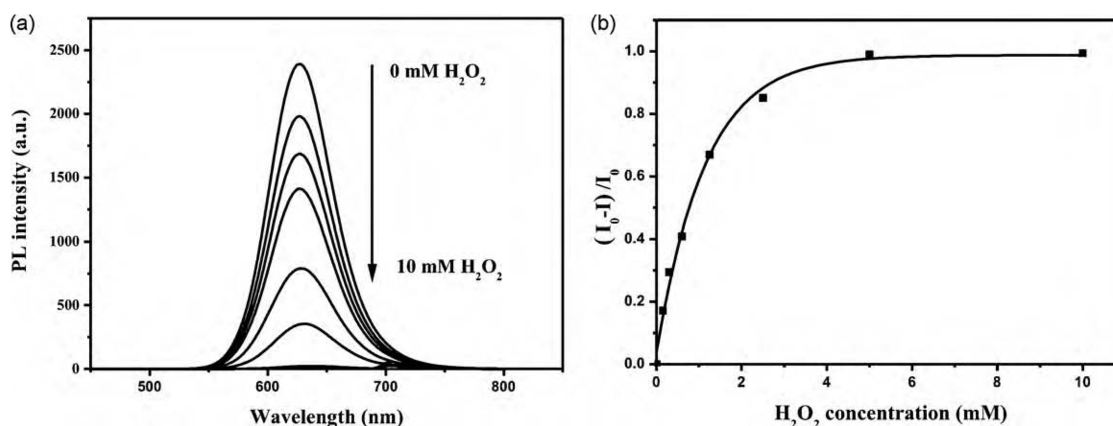


Fig. 1. (a) PL quenching of MPA-capped CdTe/CdS QDs upon stepwise addition of H_2O_2. All spectra were recorded under the identical experimental conditions at a QD concentration of 10 μM excited at 350 nm. (b) Plot of the quenching efficiency $[(I_0 - I)/I_0]$ of the QDs versus the concentrations of H_2O_2, where I_0 and I are the PL intensities of the QDs in the absence and presence of H_2O_2, respectively. The quenching curve was fitted by a Boltzmann model.

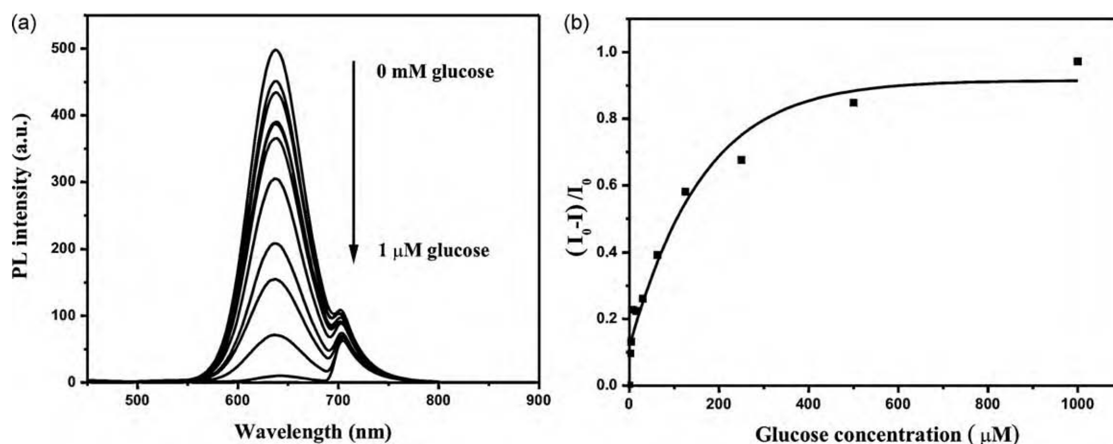


Fig. 2. (a) PL quenching of MPA-capped CdTe/CdS QDs upon stepwise addition of glucose. All spectra were recorded under the identical experimental conditions at a QD concentration of 10 μM and GOx concentration of 20 μg/mL excited at 350 nm. The fluorescence peak at 700 nm is scattered source light (350 nm) being detected due to second order diffraction. (b) Plot of the quenching efficency $[(I_0 - I)/I_0]$ of the QDs versus the concentrations of glucose, where I_0 and I are the PL intensities of the QDs in the absence and presence of glucose, respectively. The quenching curve was fitted by a Boltzmann model.

Regardless of these differences in quenching behavior, both sets of QDs examined in this study successfully detected changes in H_2O_2 concentration.

3.2. Detection of glucose by the quenching PL emission of CdTe/CdS QDs

The sensitive response of QDs to H_2O_2 led to the development of versatile QD-based fluorescent sensors for the activities of oxidases and for the detection of their substrates. GOx catalyzed the oxidation of D-glucose to gluconic acid by utilizing molecular oxygen as an electron acceptor with simultaneous production of H_2O_2. Based on this point, the biocatalyzed oxidation of glucose could be monitored by following the effect of the generated H_2O_2 on the QDs PL. The PL spectra representing the quenching effects of glucose on the QDs PL in the presence of GOx were shown in Fig. 2. The sensor exhibited an excellent response to glucose concentrations ranging from 1.8 μM to 1 mM with a detection limit of 1.8 μM ($S/N \geq 3$), about 3 orders of magnitude lower than some established glucose detection methods [8,28–30]. When the glucose concentration was less than 125 μM, the quenching efficiency $[(I_0 - I)/I_0]$ was linear with the concentration of glucose; at higher concentration, the quenching curve tended to be flat. The tendency was in accordance with the kinetics of enzyme-catalyzed reactions, that the substrate with high concentrations would inhibit the activity of enzyme. Negative control experiments indicated that D-glucose without GOx did not affect the fluorescence of the QDs, and substitution of D-glucose with L-glucose did not affect the fluorescence of the QDs, implying that the luminescence quenching of the QDs was attributed to the biocatalyzed generation of H_2O_2.

Compared with other glucose detection strategies, this QD-based glucose detection has the advantages of low detection limit, high sensitivity and simple operations. Determination of glucose in subcutaneous tissue fluid has become one of the most popular techniques in non-invasive blood glucose measurement. Compared with the direct detection of human blood glucose (mM order of magnitude), the subcutaneous glucose levels are very low leakage (μM order of magnitude). Based on this point, this proposed method with 1.8 μM detection limit has the potential in non-invasive blood glucose measurement.

Several detection conditions were optimized to achieve sensitive sensing of glucose. Since pH plays an important role in the enzymatic reaction, the effect of pH on the enzymatic reaction was studied. We compared the quenching effects of glucose on the QDs PL over the wide pH range from 5.0 to 10.0. The quenching efficiency reached maximum at pH 7.5, so 150 mM PB with pH value of 7.5 was used as reaction buffer throughout.

3.3. Detection of glucose in 96-well plates

Due to the uncomplicated principle and construction of this glucose sensor, the detection was not strict with the analytical instrument and reaction container. To simplify the detection procedure and model the portable blood sugar detector, 96-well plates were chosen as reaction container instead of colorimetric cuvettes. Under the illumination of ultraviolet (UV), the procedure and results of measurement were visualized due to the fluorescent property of the QDs. Significantly, with the increase of glucose concentrations ranged from 2 to 30 mM, the PL arising from the QDs decreased (Fig. 3). Three groups of replicative experiments were highly consistent.

All of the PL signals in the 96-well plates could be read and analyzed simultaneously with automatic microplate reader (Tecan GENios fluorometer). Based on this point, quantitative, accurate and high-throughput detection of glucose based on QDs in 96-well plates was easily to achieve. As shown in Fig. 4, the data in the

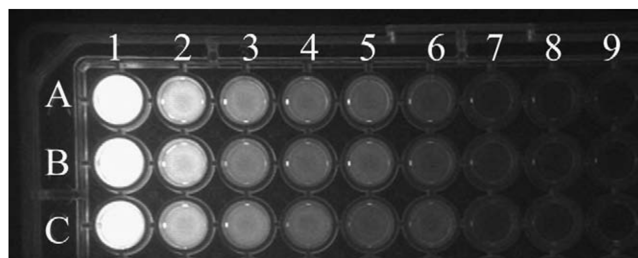


Fig. 3. Detection of glucose in 96-well plate. Each well was loaded with QDs (10 μM, 10 μL) and GOx (20 μg/mL, 100 μL). The concentrations of glucose were 0, 2, 4, 6, 8, 10, 20, and 30 mM from column 1 to 9. Rows A, B and C were three groups of replicative experiments. The plate was illuminated by UV and the photograph was captured by Cannon digital camera.

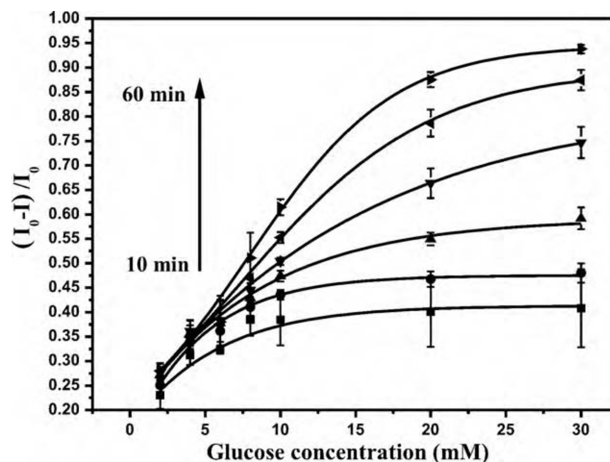


Fig. 4. The PL quenching of QDs with different concentrations of glucose and reaction time. Each calibration curve was fitted by a Boltzmann model. The detection was carried out in 96-well plates and the data were read with automatic microplate reader.

96-well plates were collected and the calibration curves were fitted by Boltzmann model. Although the sensitivity and detection range were not comparable with that of detection in colorimetric cuvettes, this method was quite competent for detection of glucose in biological systems, given the physiological concentration of glucose in normal blood circulation ranged from 3 to 20 mM. The enzymatic reaction, diffusion of H_2O_2 and oxidation of MPA were dynamic processes. As a result, the reaction time, counted when a glucose solution was added into the QDs and GOx mixture, directly affected the quenching efficiency and the sensitivity of the glucose sensor. Signals of different glucose concentrations (from 2 to 30 mM) at different reaction time (from 10 to 60 min with an interval time of 10 min) were recorded (Fig. 4). Evidently, the quenching effect was boosted up with the reaction time.

To further evaluate the credibility of the proposed glucose assay, a comparative study with the commercialized glucose meter (Accu-Chek, Roche) in measuring glucose of standard samples was performed. Four standard samples with known glucose concentrations were detected by Accu-Chek. Then we tested these four samples with the above mentioned glucose assay. The glucose concentrations were deduced from the calibration curve and the regression equation. The measured values were summarized in Table 1. As shown in Table 1, the results obtained by the QD-based glucose assay showed reasonable agreements with the standard values. Their relative standard deviations (R.S.D. < 5%) were comparative with that of Accu-Chek. This comparison indicated that the proposed sensor is reliable for the detection of glucose.

Some analogous researches have been reported based on different nanomaterials or different detection schemes [37–42]. Detailed

Table 1
Determination of glucose standard samples by Accu-Chek and QD-based assay. The concentrations were expressed as mean ± S.D. R.S.D. was calculated as (S.D./mean) × 100%.

Glucose concentration (mM)	Content detected by Accu-Chek (mM)	R.S.D. (%) (n = 5)	Content detected by the proposed sensor (mM)	R.S.D. (%) (n = 5)
3.9	3.8 ± 0.07	1.8	4.1 ± 0.13	3.4
4.6	4.4 ± 0.14	3.2	4.9 ± 0.22	4.5
7.8	7.5 ± 0.20	2.7	8.2 ± 0.29	3.5
16.5	16.0 ± 0.35	2.2	17.3 ± 0.57	3.3

Table 2
Comparison of the performance of nanomaterials-based glucose sensing methods.

Nanomaterials	Enzyme immobilization	Detection scheme	Detection range	LOD	Reference
CdTe QDs	Not needed	Fluorescence quenching by H_2O_2	1.0 μM to 0.5 mM and 1–20 mM	0.1 μM	[37]
Ag/CNT/Ch film	LbL assembly	Amperometry	0.5–50 μM	0.1 μM	[38]
CdTe/ZnS QDs	Not needed	Fluorescence quenching by acidic change	0.2–10 mM and 2–30 mM	Not given	[39]
CdTe film	LbL assembly	Fluorescence quenching by H_2O_2	0.5–16 mM	0.5 mM	[40]
CdTe QDs	Not needed	Fluorescence quenching by benzoquinone	1 μM to 0.15 mM and 0.15–1 mM	0.01 μM	[41]
Mn-doped ZnS QDs	Covalent conjugation	Phosphorescence quenching by H_2O_2	10 μM to 0.1 mM and 0.1–1 mM	3 μM	[42]
CdTe/CdS QDs	Not needed	Fluorescence quenching by H_2O_2	1.8 μM to 1 mM and 2–30 mM	1.8 μM	This work

Table 3
Determination of glucose in blood samples by Accu-Chek and QD-based assay. The concentrations were expressed as mean ± S.D. R.S.D. was calculated as (S.D./mean) × 100%.

Sample	Content detected by Accu-Chek (mM)	R.S.D. (%) (n = 5)	Content detected by the proposed sensor (mM)	R.S.D. (%) (n = 5)
1	5.2 ± 0.09	1.7	5.8 ± 0.45	7.7
2	5.8 ± 0.12	2.0	6.5 ± 0.52	8.0
3	6.3 ± 0.14	2.3	7.0 ± 0.51	7.4
4	8.5 ± 0.21	2.5	9.4 ± 0.67	7.1

comparisons of these glucose detection methods were listed in Table 2. Compared with these methods, our detection system has shown some advantages and novelties. First, the detection ranges are rather wide, as glucose with concentration from 1.8 μM to 1 mM and 2–30 mM could be quantified. These detection ranges covered the concentrations of glucose in both subcutaneous tissue fluid and normal blood circulation, which made our system suitable for both non-invasive and direct blood glucose measurement. Second, the detection limit of this proposed method was much lower than some methods [39,40]. In addition, immobilization of enzymes by covalent conjugation [42] or Layer-by-Layer (LbL) assembly [38,40] has been avoided in our detection system. Also, the proposed method exhibited excellent reproducibility with the low R.S.D. Moreover, the detection carried out in 96-well plates makes the measurement more convenient and portable.

3.4. Interference effect

Our previous work proved that certain metal ions such as Hg^{2+}, Ag^{+}, Cu^{2+}, Fe^{3+}, Pb^{2+} with concentration of 10 μM intensively quenched the PL emission of CdTe/CdS QDs, and these metal ions interfered with the glucose detection. Some metal ions such as K^{+}, Na^{+}, Mg^{2+} with concentration of 100 mM exhibited no obvious influence on QDs PL emission, and had no obvious interference with the glucose detection.

In addition, some biomolecules present in the blood serum like ascorbic acid (AA) and uric acid (UA) were also investigated for any possible interfering effects on the analysis of glucose. The different concentrations of AA or UA were added to 5 mM glucose solution and then the glucose concentration was measured with our QD-based assay. It was found that AA and UA have no significant interfering effects on the analysis of glucose up to 0.5 and 5 mM (data not shown). Considering the concentrations of AA and UA in normal serum are around 0.05 and 0.5 mM, respectively [43], the use of our proposed method for determining glucose will not be interfered by these substances.

3.5. Determination of glucose in blood and urine

To investigate the feasibility of this sensing system for analysis glucose in biological fluids, glucose concentrations in human blood samples were measured. In view of hemoglobin and other protein in serum are prone to absorb onto the surface of QDs and interfere with the QDs PL emission, we blocked the QDs with 10% (w/v) BSA to decrease the non-specific absorption between protein and QDs [15,44]. Detection was carried out as previously described. Unknown concentrations of blood glucose detection results were listed in Table 3. It can be seen that the glucose concentrations determined by the current method were close to the values provided by Accu-Chek. The substances in the serum have little interfering effects on the effective use of this glucose sensor.

Blood glucose monitoring and urine glucose monitoring are the two primary methods used by the person with diabetes to monitor their diabetes control. Urine glucose monitoring is not a substi-

Table 4
Determination of glucose in artificial urine by Accu-Chek and QD-based assay. The concentrations were expressed as mean ± S.D. R.S.D. was calculated as (S.D./mean) × 100%.

Glucose concentration (mM)	Content detected by Accu-Chek (mM)	R.S.D. (%) (n = 5)	Content detected by the proposed sensor (mM)	R.S.D. (%) (n = 5)
3	3.3 ± 0.05	1.5	3.4 ± 0.14	4.0
5	5.3 ± 0.11	2.1	5.4 ± 0.28	5.2
7	7.4 ± 0.18	2.4	7.6 ± 0.40	5.3
12	12.4 ± 0.30	2.4	12.5 ± 0.62	5.1

tute for blood glucose monitoring, but rather an alternative or complement which can provide very valuable information where blood glucose monitoring is not accessible, affordable, or desired. To broaden the application field of our glucose sensing system, glucose concentrations in artificial urine were examined. Detection was carried out as described above. The results for detecting the urine glucose were listed in Table 4. The effectively determination of glucose in both blood and urine samples has implied that this QD-based glucose detection method has potential in clinical diagnosis.

4. Conclusions

In summary, we have utilized the water-dispersible MPA-capped CdTe/CdS QDs as a reliable agent for the enzymatic detection of glucose concentration. A mechanism is put forward based on the fluorescence quenching of the QDs, which is caused by the H_2O_2 that is produced from the GOx-catalyzed oxidation of glucose. Compared with other glucose detection reported in the literature, this QD-based assay exhibits several advantages. First, enzyme immobilization and QDs modification process are not required. The whole detection system is based on simply mixing QDs and GOx. Second, the high PLQY of the QDs and their stability towards photobleaching are beneficial to this sensing system. Third, this QD-based assay can sensitively detect glucose over a wide concentration range from micro- to millimolar with the detection limit of 1.8 μM, which can be used for the direct detection of lower levels of glucose in complicated biological systems. Moreover, the detection carried out in 96-well plates makes the measurement more convenient and portable. Given these unparalleled advantages, we expect that this QD-based label-free assay will be a promising tool for clinical diagnose of glucose and other fields.

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