

Composites based on solid sulfides solutions of Cd and Zn and graphitic carbon nitride for the photocatalytic hydrogen evolution under visible light irradiation

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INTRODUCTION

Graphitic carbon nitride (g-C₃N₄) is one of the most interesting materials for the photocatalytic water splitting under visible light irradiation, as it has many advantages over the already used photocatalysts but, despite a large number of advantages, g-C₃N₄ has one significant disadvantage — fast recombination of charges on the catalyst surface. To provide spatial separation of photogenerated charges, composite semiconductor materials are created.

GOAL

The aim of this work was to create ternary highly active complex photocatalysts based on composite materials Cd_{1-x}Zn_xS/g-C₃N₄ and Pt for obtaining hydrogen under visible light, as well as to understand the role of Pt and the type of implemented heterojunctions.

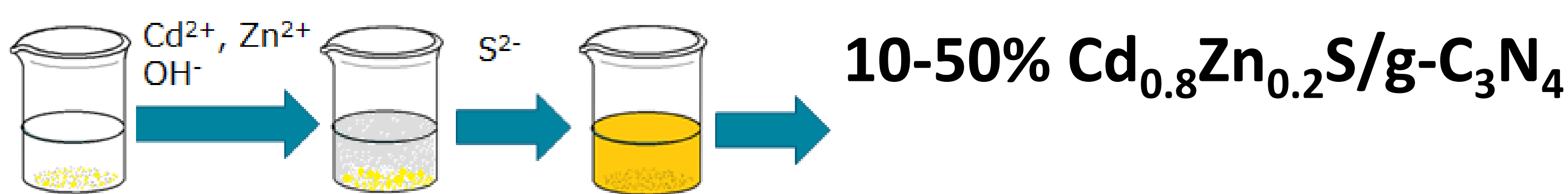
MATERIALS AND METHODS

Synthesis

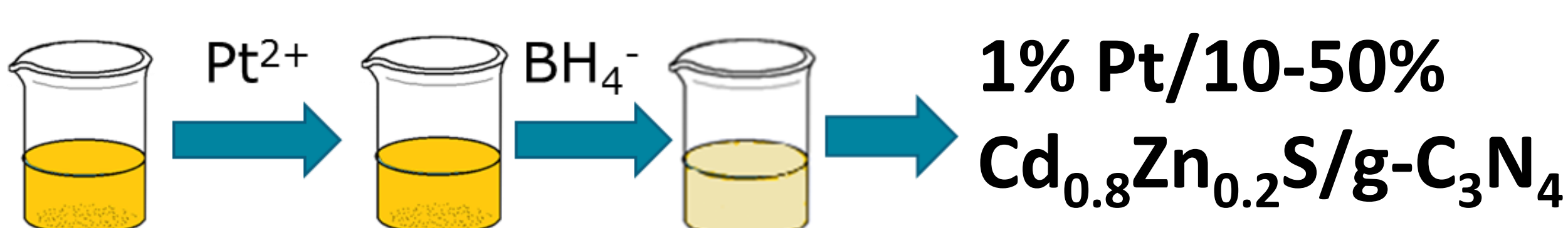
g-C₃N₄ was obtained from melamine with a calcination time of 600 °C and a heating rate of 5 °C/min for 2 hours.

Synthesis of Scheme 1:

Deposition of Cd_{0.8}Zn_{0.2}S:

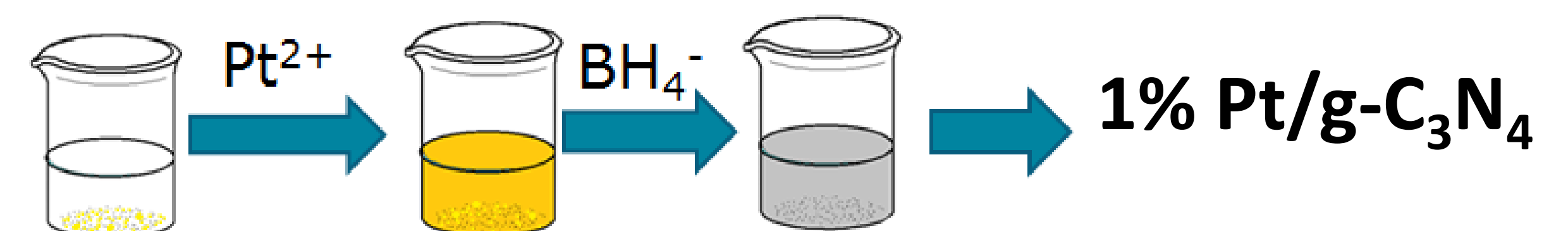


Deposition of Pt:

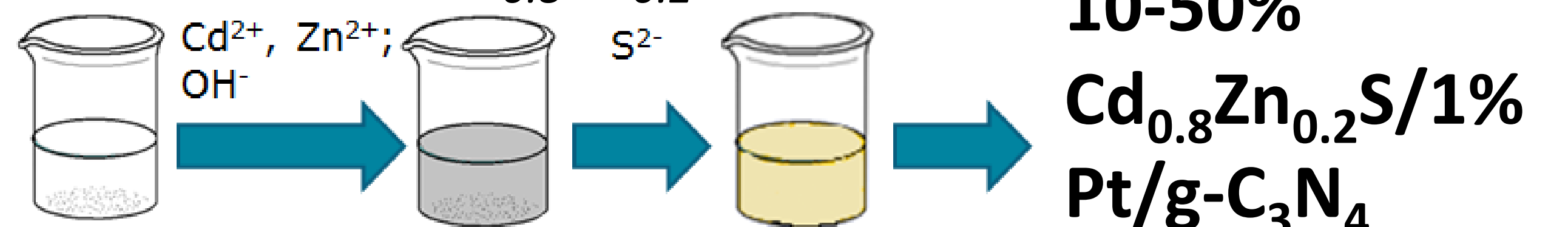


Synthesis of Scheme 2:

Deposition of Pt:



Deposition of Cd_{0.8}Zn_{0.2}S:



RESULTS

Kinetic experiments

The photocatalytic activity of synthesized samples was tested in the hydrogen evolution from aqueous alkaline triethanolamine (TEOA) solutions. 50 mg of the photocatalyst was suspended in a solution that contained 10 ml of triethanolamine and 90 ml of 0.1 M NaOH. The obtained suspension was illuminated under visible light with a 450-LED.

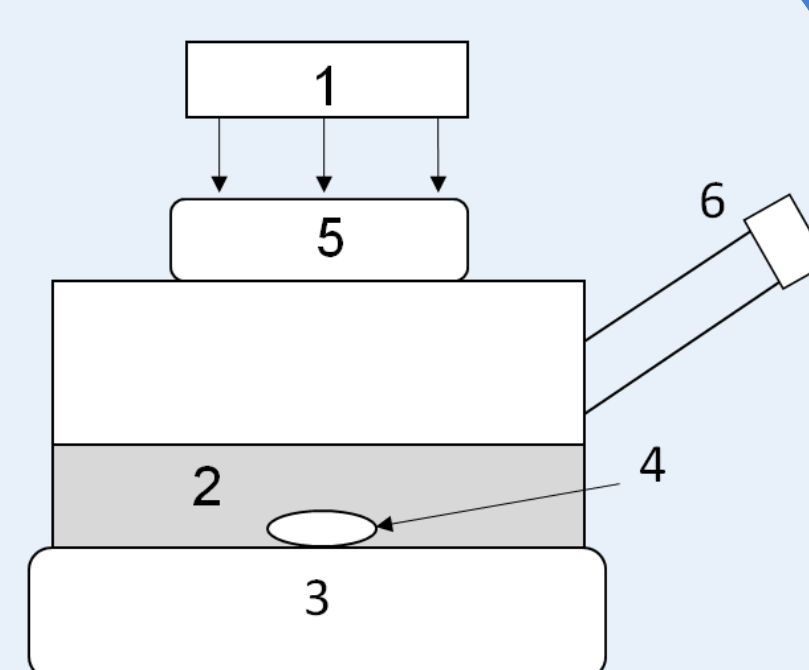


Fig. 1. The reaction set-up: 1. 450-nm LED, 2. Suspension, 3. Magnetic stirrer, 4. Anchor, 5. Quartz window, 6. Sampler

Catalyst characterization

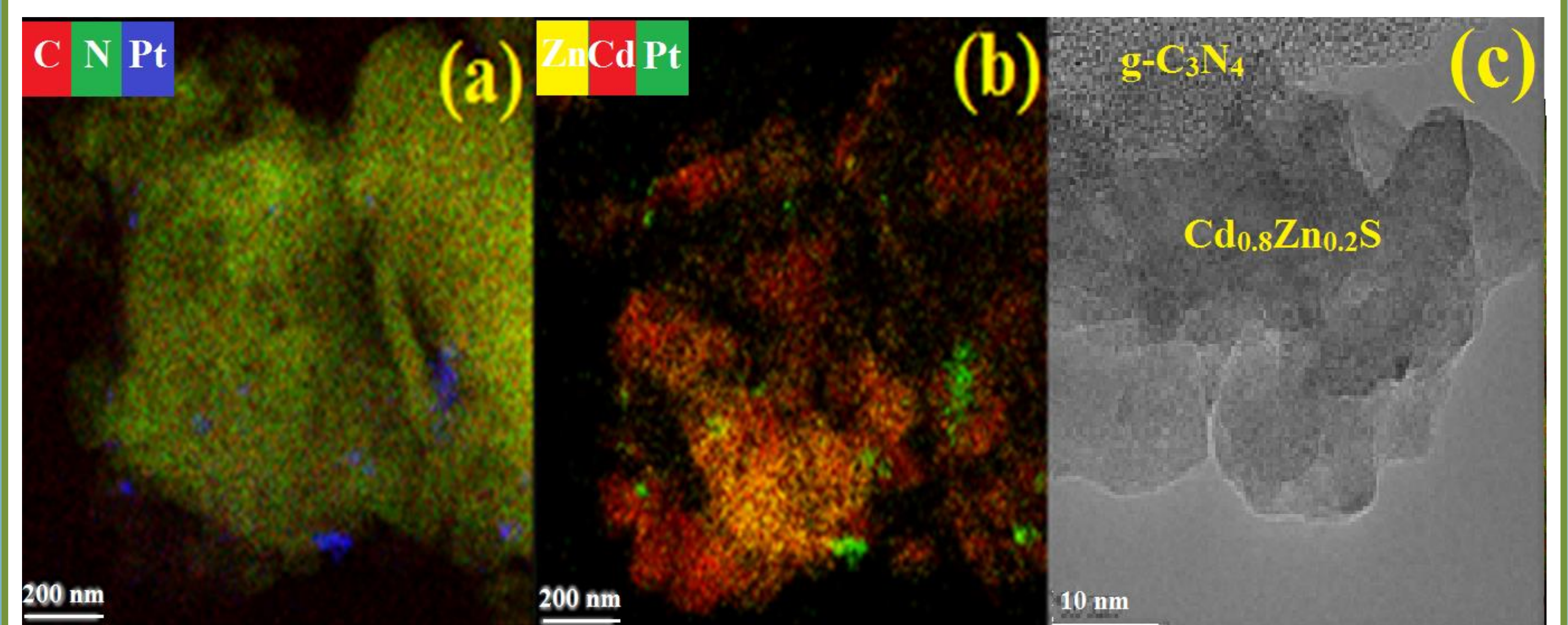


Fig. 2. Elemental mapping of (a-b) and HRTEM image (c) of the photocatalyst synthesized according to Scheme 2 — 20% Cd_{0.8}Zn_{0.2}S/1% Pt/g-C₃N₄

Photocatalytic experiments

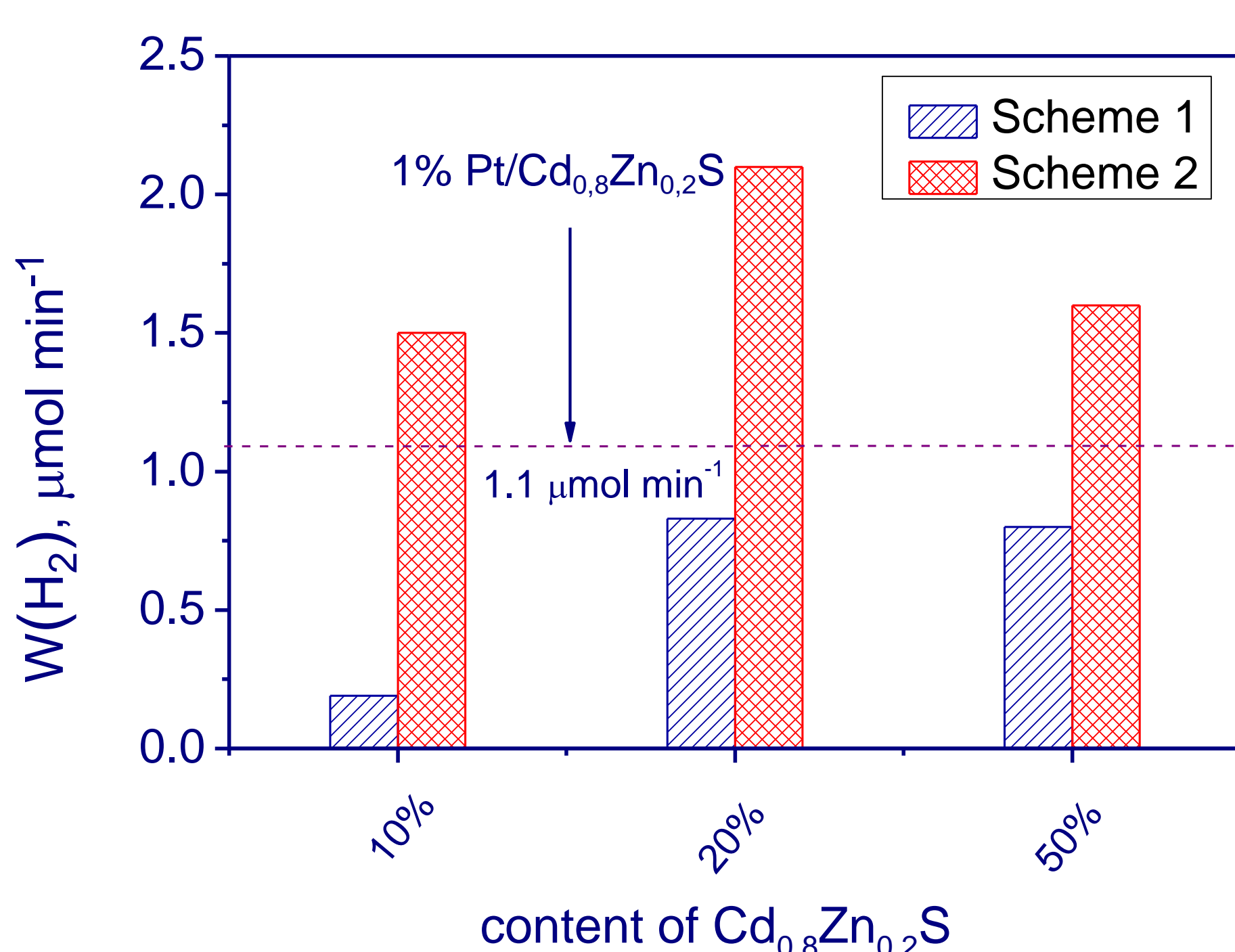


Fig. 4. The activity of the photocatalysts synthesized according to Scheme 1 — 1% Pt/10-50% Cd_{0.8}Zn_{0.2}S/g-C₃N₄ and Scheme 2 — 10-50% Cd_{0.8}Zn_{0.2}S/1% Pt/g-C₃N₄

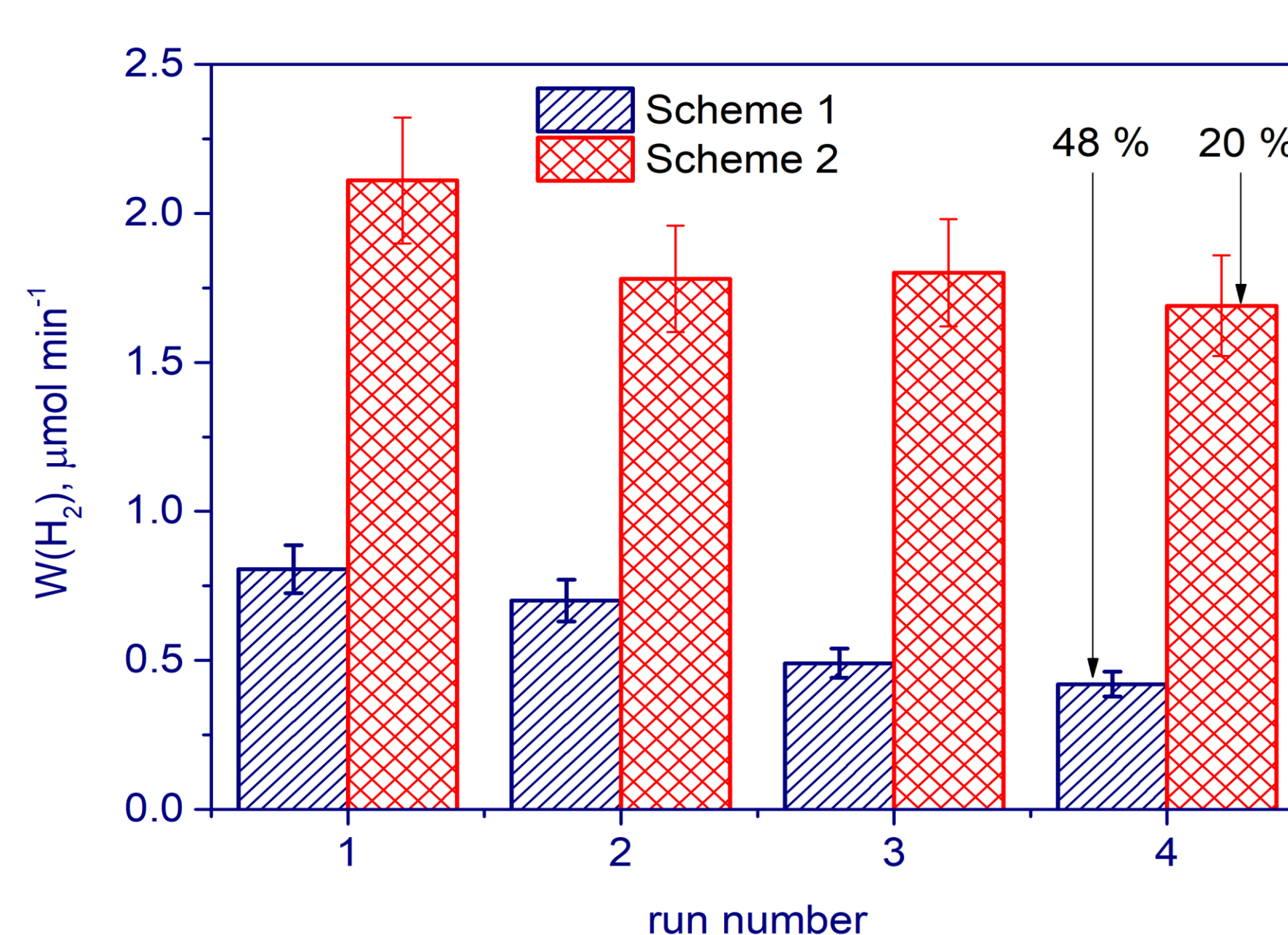


Fig. 5. The stability of the photocatalysts in four 1.5 h consecutive hydrogen evolution runs

CONCLUSIONS

The activity of the all photocatalysts 10-50% Cd_{0.8}Zn_{0.2}S/1%Pt/g-C₃N₄ (Scheme 2) was much higher than that of the 1% Pt/10-50% Cd_{0.8}Zn_{0.2}S/g-C₃N₄ photocatalysts (Scheme 1). The 20% Cd_{0.8}Zn_{0.2}S/1%Pt/g-C₃N₄ sample showed the maximum H₂ evolution rate equal 2.5 mmol g_{cat}⁻¹ h⁻¹ with apparent quantum efficiency equal to 6.0%. This is due to the fact that for more active photocatalysts the mechanism of interphase heterojunctions according to the Z-scheme is most likely realized, while photocatalysts with low activity are characterized by type II heterojunctions. Moreover, Z-scheme photocatalysts have greater stability than that of type II heterojunction photocatalysts.

ACKNOWLEDGEMENTS

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