Photoinduced Enhancement of the Photoluminescence of Nano-ZnO in a Conductive Polymer

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Motivation

✓ Organic-inorganic nanocomposites – new materials combining the advantages of polymers and nanoparticles;

✓ ZnO nanoparticles (NPs) are widely employed in the fundamental research and commercial applications;

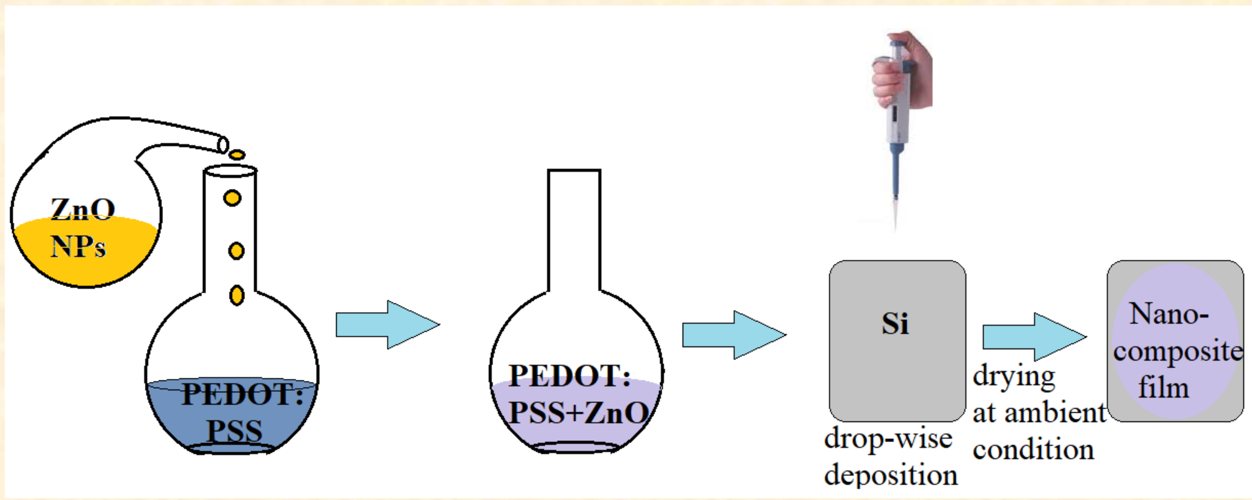
✓Using of conductive matrix in ZnO-containing nanocomposite is necessary for optoelectronic devices.

Goal

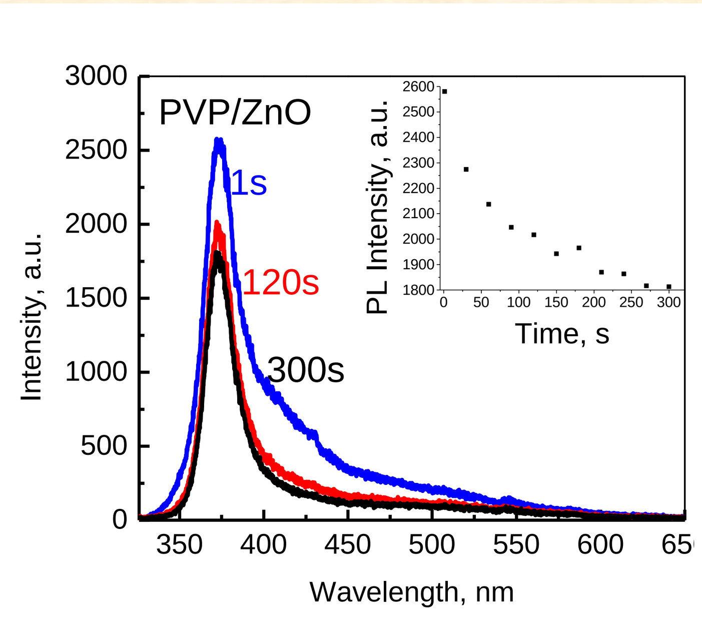
To incorporate ZnO nanoparticles a conductive matrix, to study the applicability of the nano-composite as a luminescent material and to compare its light-emitting properties with nanocomposites based on dielectric matrices.

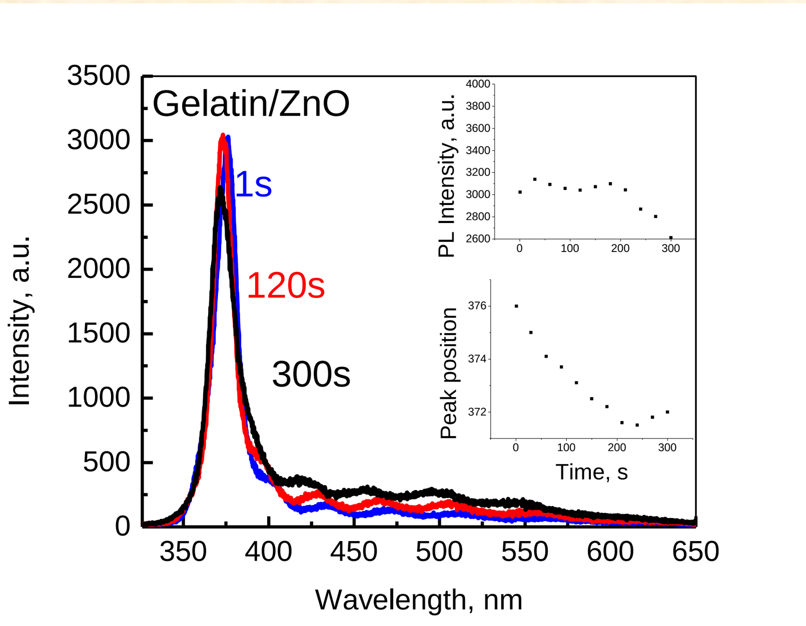
Nanocomposite fabrication

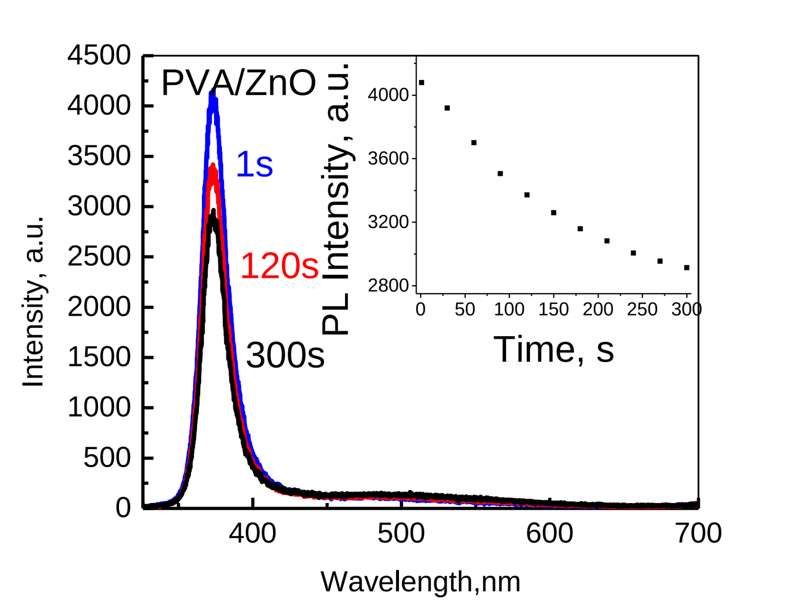
- Colloidal solution of ZnO NPs was prepared by a known method, which is described in detail in [1]; size of ZnO NPs ~ 5 nm;
- Nanocomposite solution was fabricated by mixing the colloidal solution of ZnO NPs with a polymer (PEDOT:PSS or PVP, gelatin, PVA) in the ratio 1/3;
- The solutions were drop-wise deposited on silicon substrates and dried at ambient conditions.



Evolution of PL spectra in ZnO-containing nanocomposites based on dielectric matrices under UV irradiation



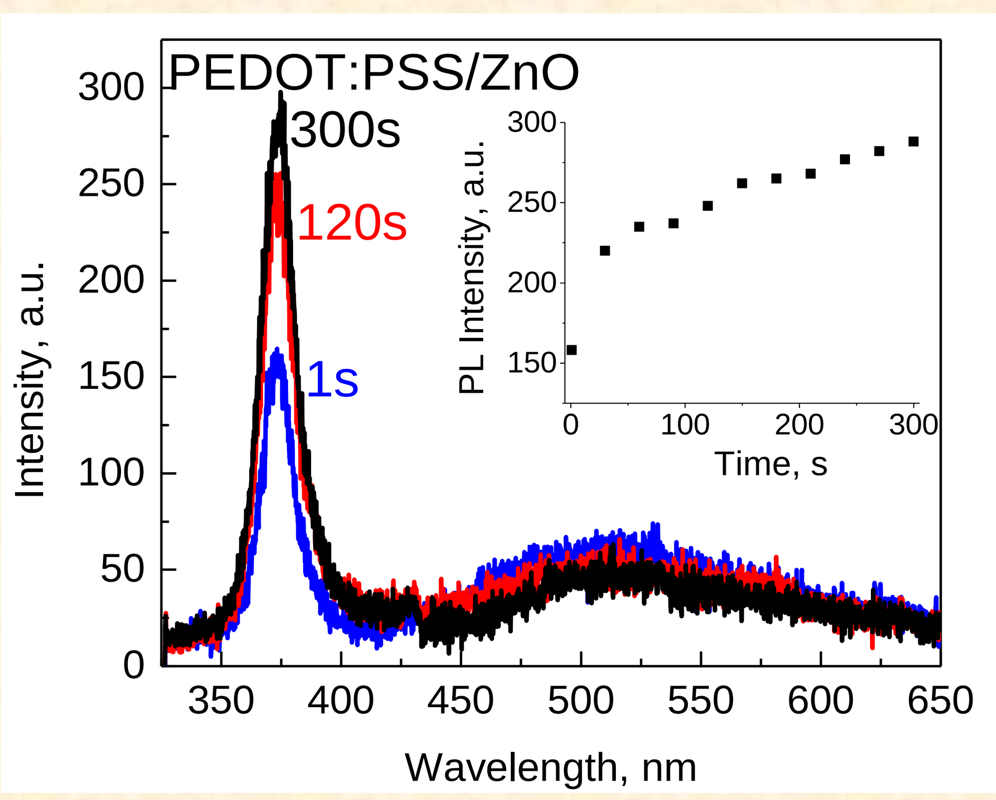




Parameters of UV light:

- Wavelength: 325 nm (He-Cd laser)
- Power: ~ 0.04 mW
- Irradiation time from 1s to 300 s.

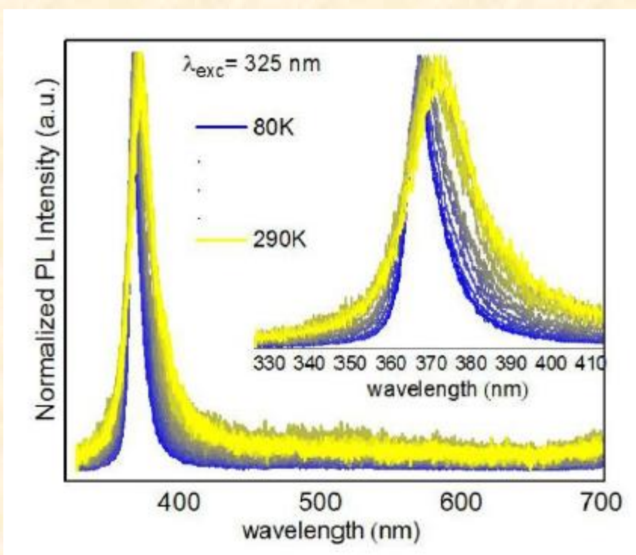
Evolution of PL spectra in ZnO-containing nanocomposites based on conductive matrix under UV irradiation



Nanocomposite ZnO nanoparticles in the conductive matrix poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS).

Main spectroscopic results

- Two PL bands are observed in **all** nanocomposites:
  Peak at 375nm – excitonic PL (EPL);
  Peak at 500nm – defect PL (DPL);
- UV-irradiation causes the **decrease** of EPL intensity in **all** nanocomposites based on **dielectric** matrices;
- On the contrary, the UV-irradiation causes the **increase** of EPL intensity in nanocomposites based on the **conductive** matrix.



To exclude possible role of sample heating on photoenhancement, the T-dependence of EPL was measured. Observations:

- An EPL band shifts with increasing T;
- Intensity decreases with T.

➡ Possible heating cannot be the reason of photoenhancement

Suggestion: photoenhancement observed for the ZnO/PEDOT:PSS nanocomposite can be caused by the accumulation and redistribution of charge carriers between the ZnO NPs and the conducting matrix.

Conclusions

- ZnO-containing nanocomposites based on conductive and dielectric matrices were prepared;
- New effect of photoenhancement was observed in nanocomposites based on conductive matrix PEDOT:PSS;
- No photoenhancement was observed in nanocomposites based on dielectric matrices.
- Photoenhancement is not caused by heating;
- The most probable mechanism of photoenhancement of EPL in the composite based on PEDOT: PSS: redistribution of photoexcited charge carriers between trap states.

[1] Ya. Panasyuk, O. Rayevska, O. Stroyuk, S. Kuchmiy, V. Dzhagan, M. Hietschold and D. R. T. Zahn, Nanotechnol., 2014, 25, 075601