Solution-Based Doping of Manganese into Colloidal ZnO Nanorods

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Introduction

- *Collodial nanocrystals possess uniform morphlogies, very small sizes, and narrow size distributions, exhibits unique optical, electrical, magnetic and* ***catalytic properties.***
- *Colloidal nanocrystals were very stable and disperses well in the solution, which is largely different from the severe aggregation of the other nanomaterials.*
- *ZnO is an environmentally friendly semiconductor, Which can be be grown in a wide variety of nanostructures like rods, wires, belts etc.*
- *These nanostructures shows broad application in the field of catalysis, gas sensors, field effect transistors and so on.*
- *Many methods have been reported like thermal evaporation, vapour phase methods etc.. This paper describes a solution based synthesis to prepare uniform Mn-doped ZnO nanorods with the controlled Mn content in molar % of 1.25, 2.5 and 5%.*

Experimental Section

Colloidal Mn-Doped ZnO nanorods

Synthesis- Two step process

1. Growth of ZnO nanorods
2. Incorporation of Mn^{2+} into the nanorods

Synthesis of undoped ZnO nanorods

- $Zn(CH_3COO)_2$ + KOH

(14.75 g/60 ml of methanol) (7.4 g /32 ml of methanol)

White Colloid (ripened for three days at 70^0 C)

Mn-doped ZnO nanorods

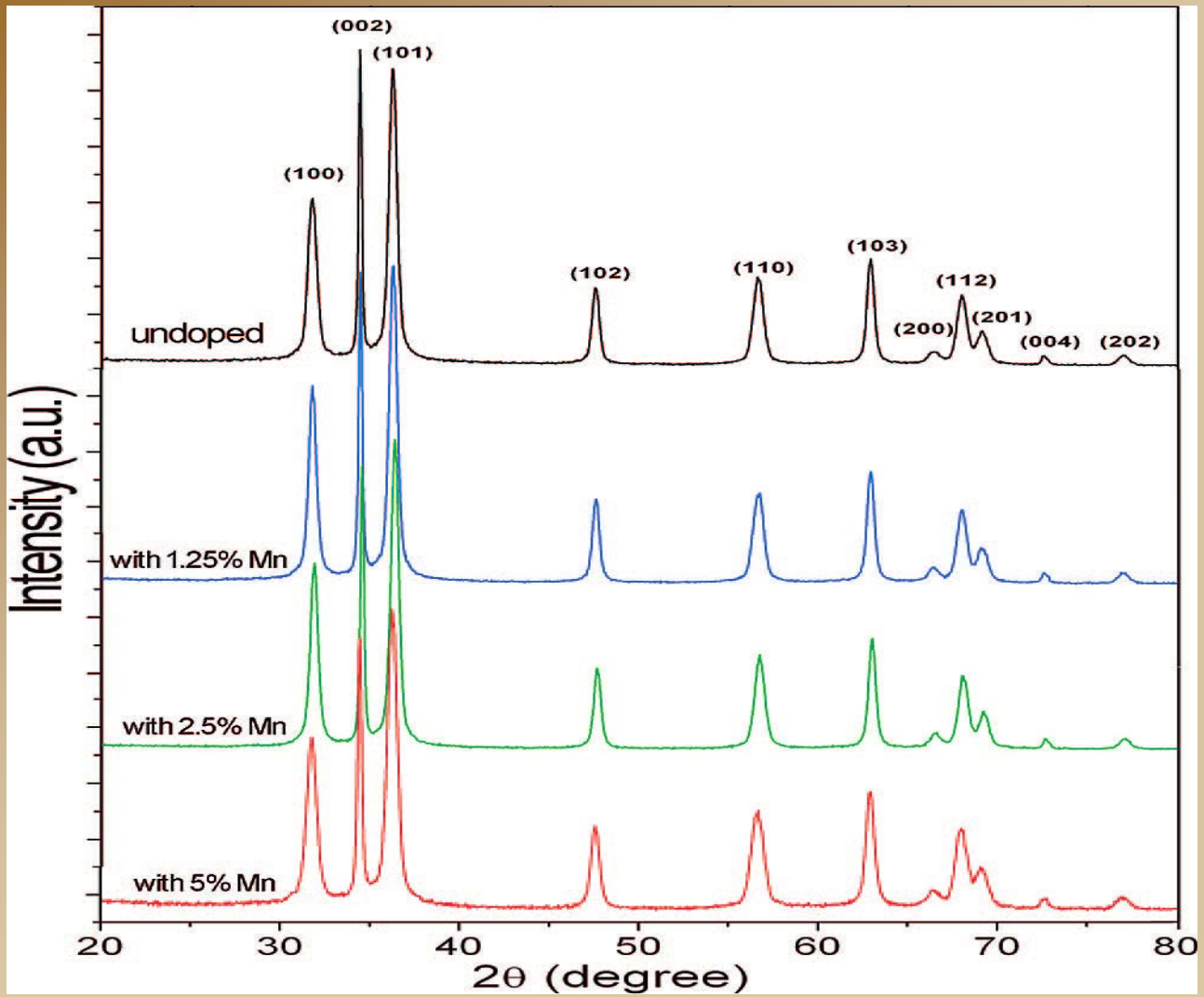
$Mn(CH_3COO)_2$ (0.17 g) + KOH (0.17 g)

↓ ZnO colloids

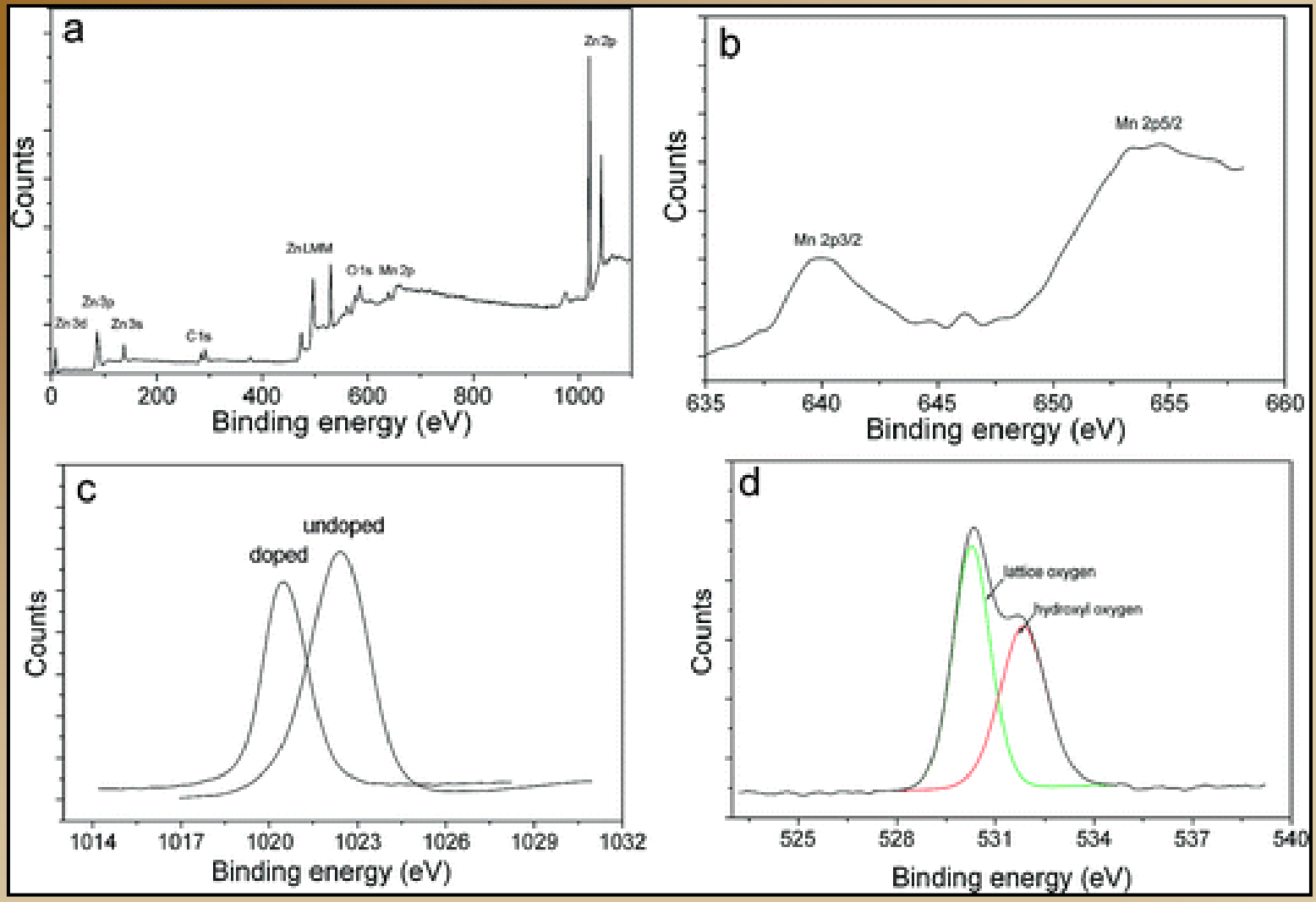
Color change from initial white to brown
(ripened at 70^0 C for 24 h)

The solids were separated from the solution by centrifugation washed several times with distilled water and alcohol to remove impurities and dried.

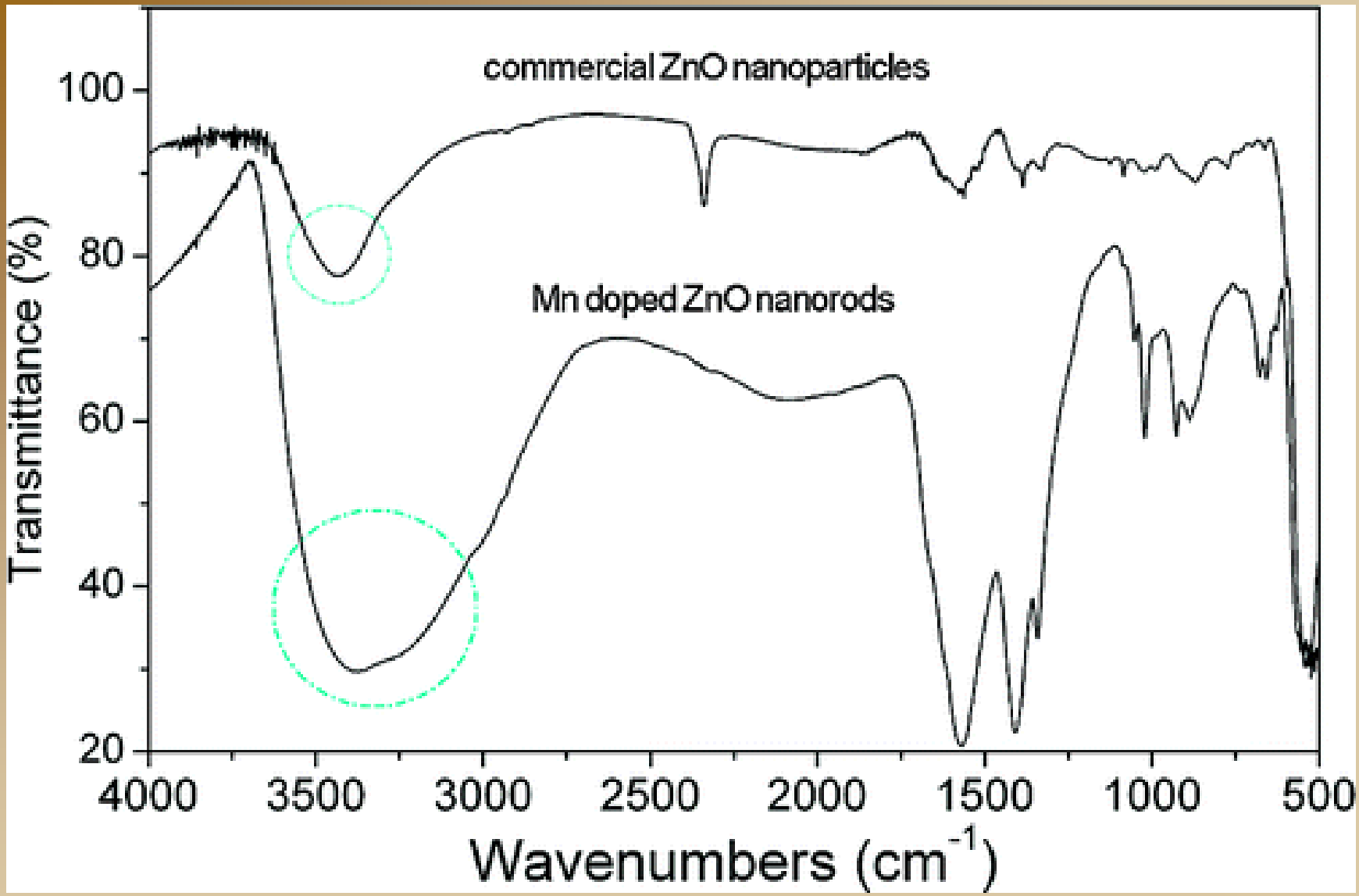
Results and Discussions



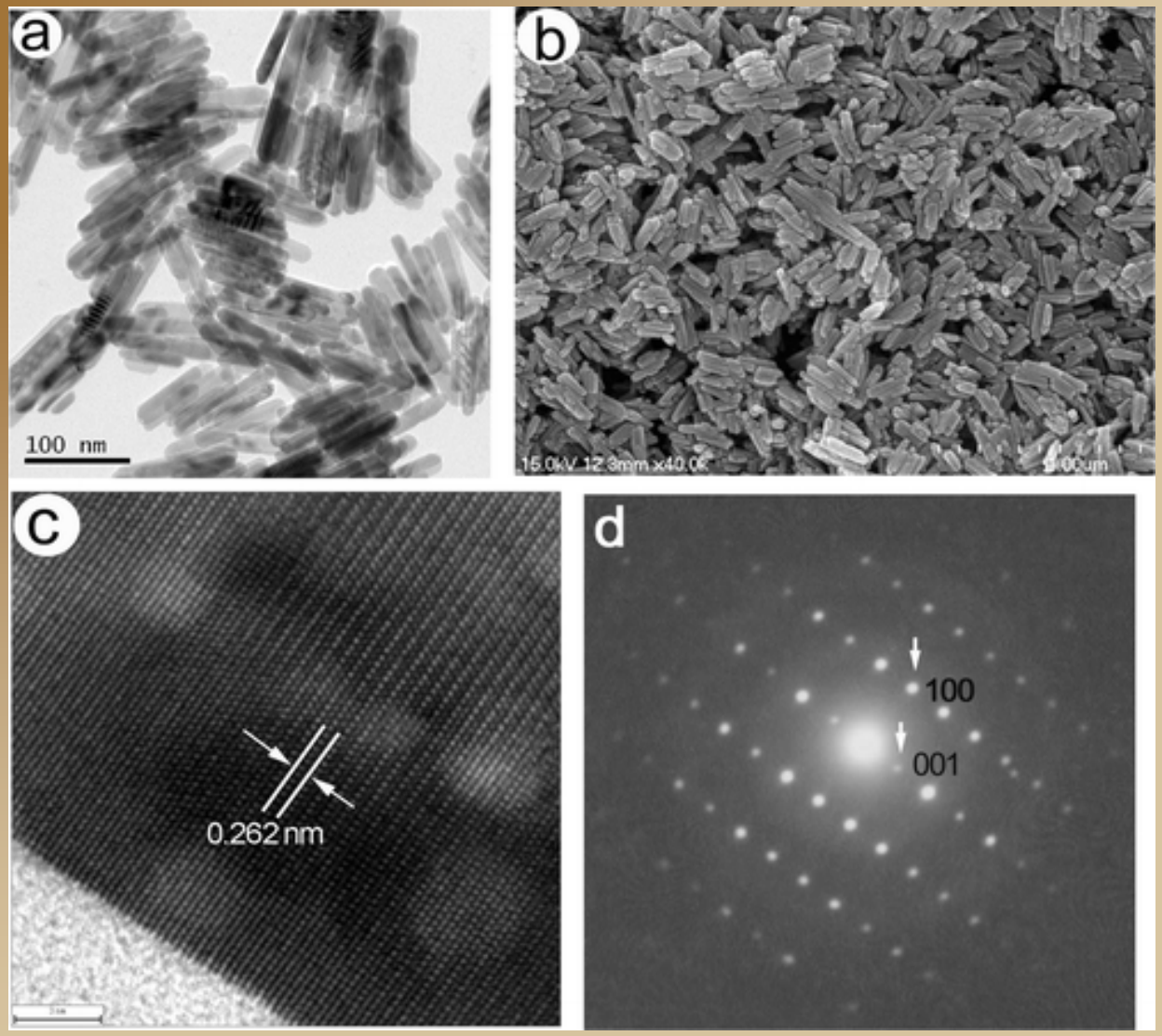
XRD patterns of undoped ZnO and those doped with different levels of Mn.



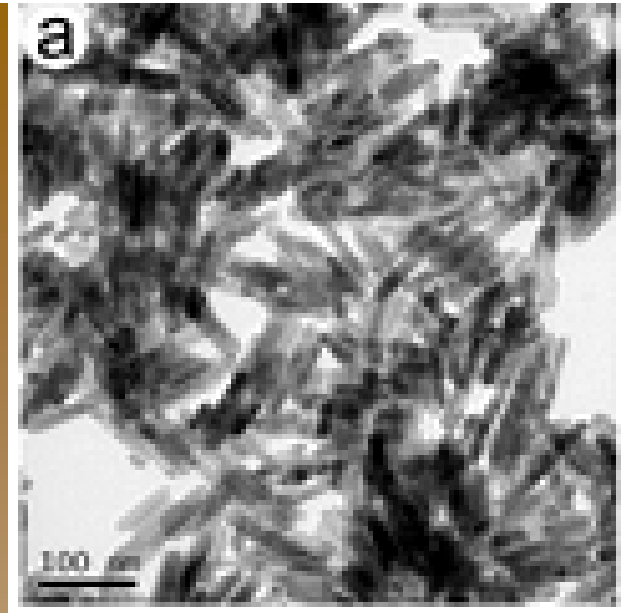
(a) XPS survey spectra of Mn-doped ZnO nanocrystals. (b) Binding energy spectrum of Mn 2p. (c) Binding energy spectra of Zn $2p_{3/2}$ of undoped ZnO and ZnO doped with 2.5% Mn. (d) Binding energy spectrum of O1s.

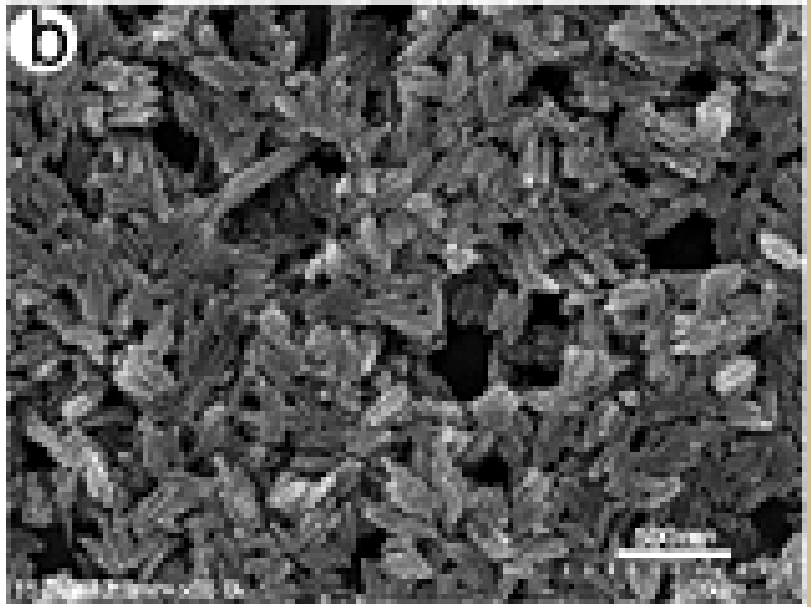


FT-IR spectra of Mn-doped ZnO nanorods and commercial ZnO nanoparticles

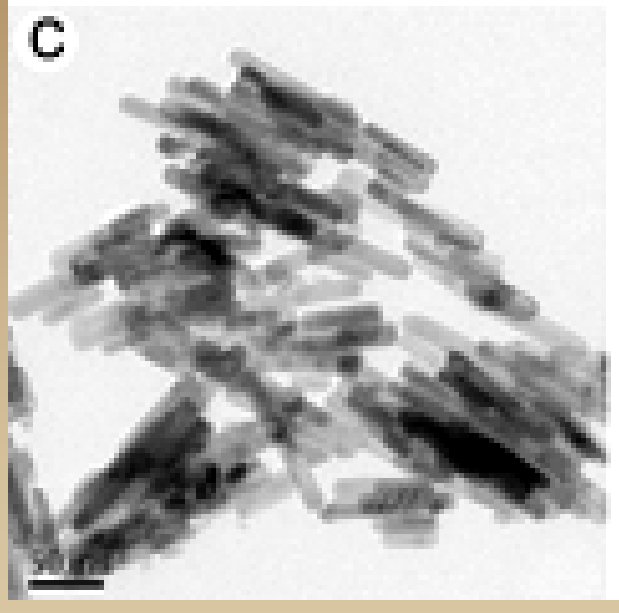


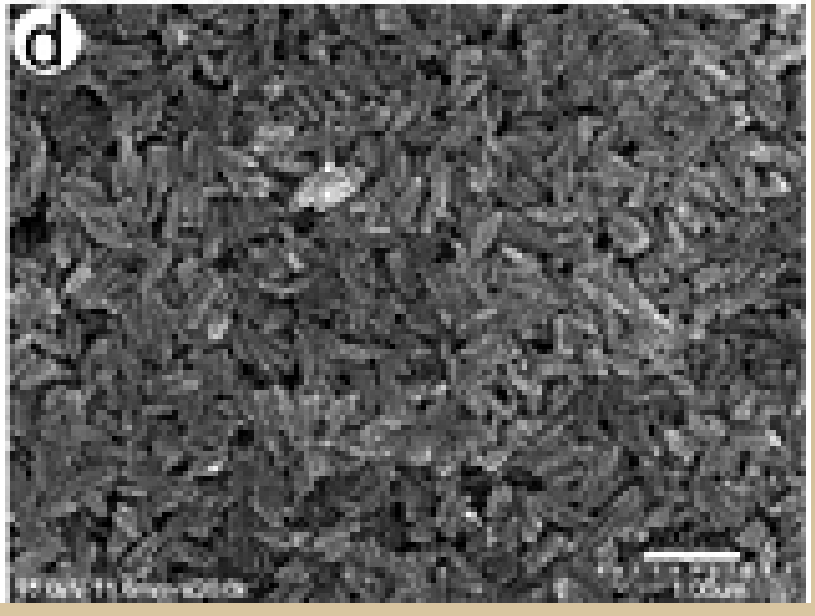
TEM (a) and FESEM (b) images of undoped ZnO nanocrystals. The products are composed of uniform nanorods. (c) Representative HRTEM image of undoped ZnO nanorods. (d) Corresponding SAED pattern.





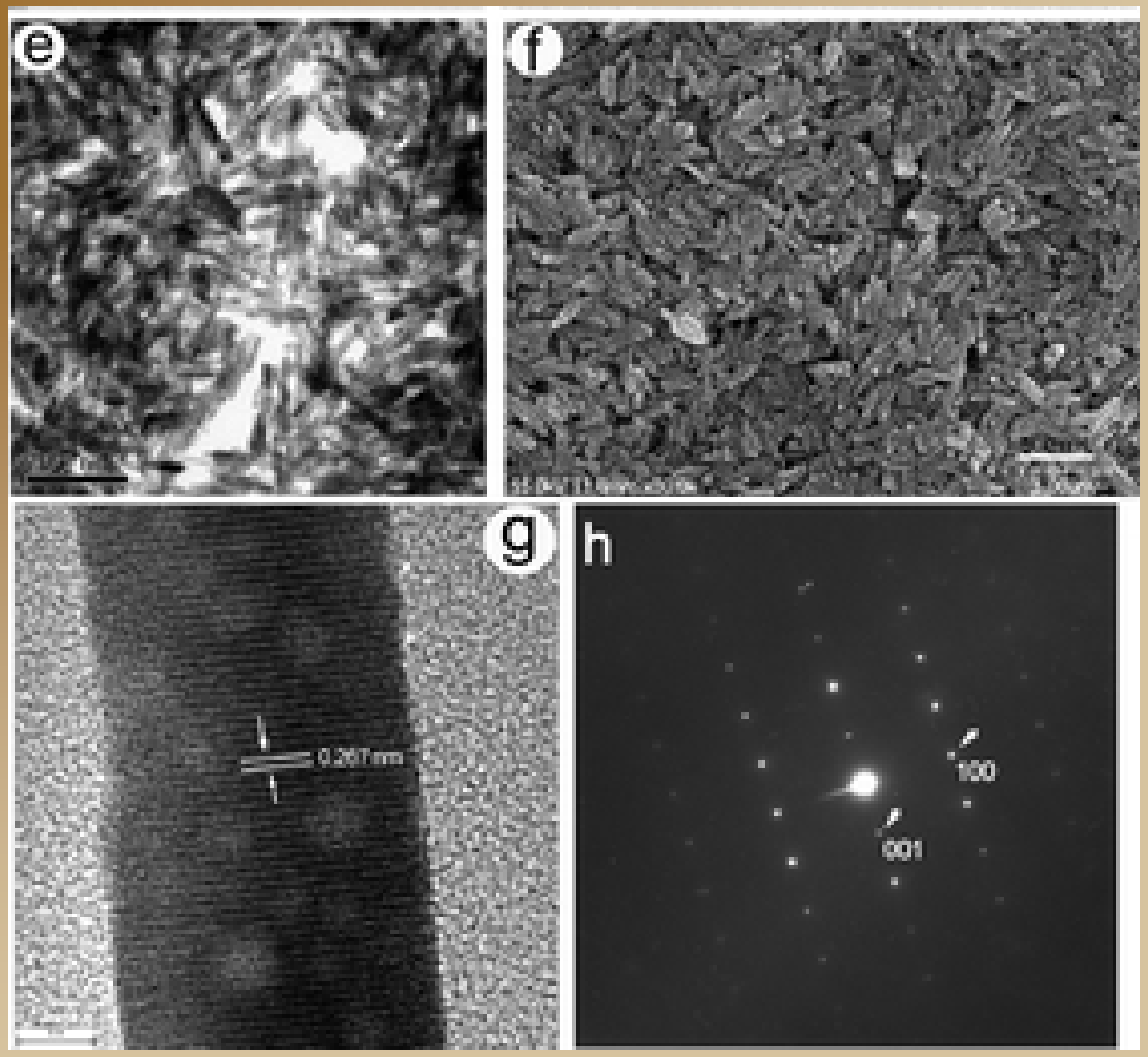
(a, b) with 1.25% Mn



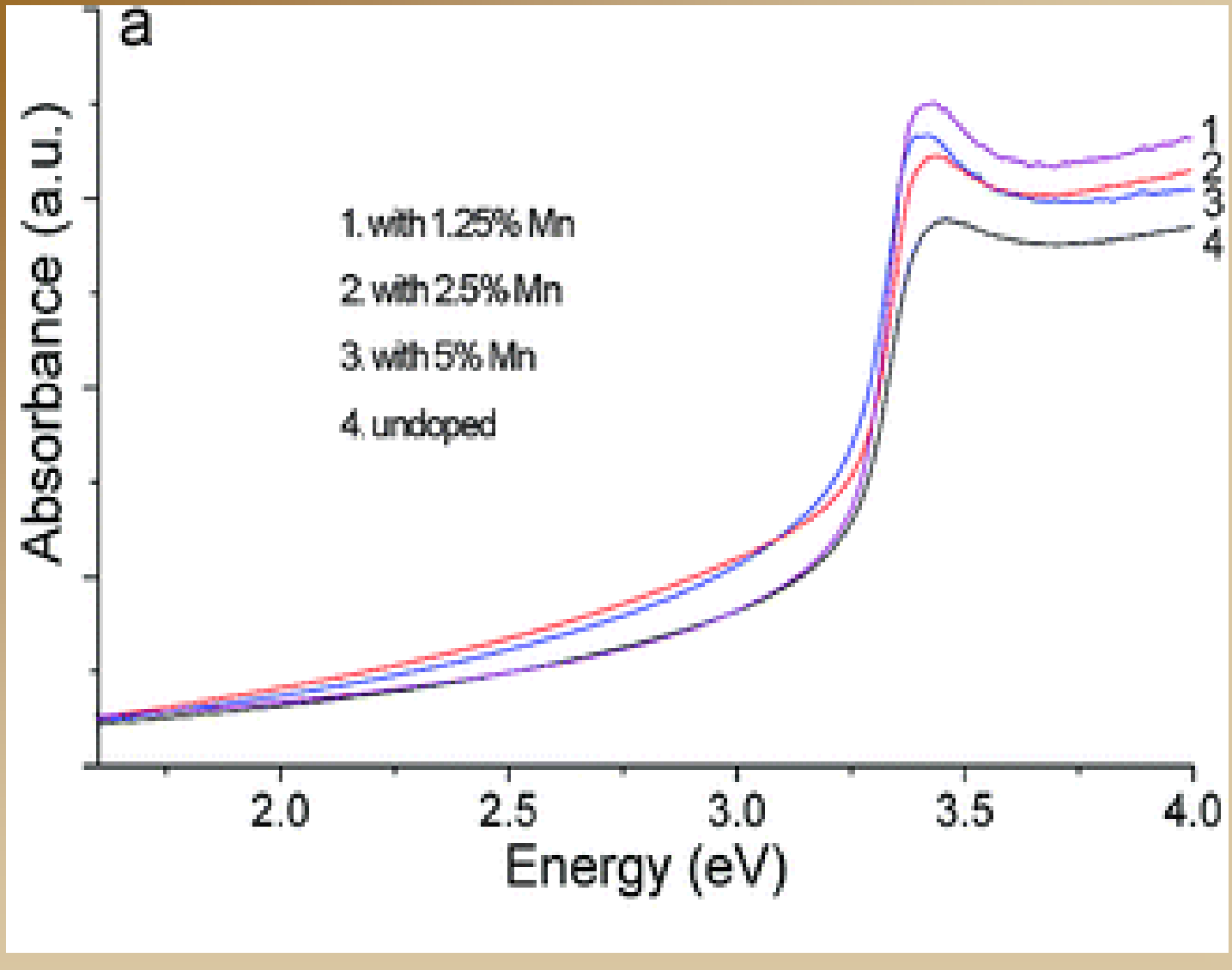


(c, d) with 2.5% Mn

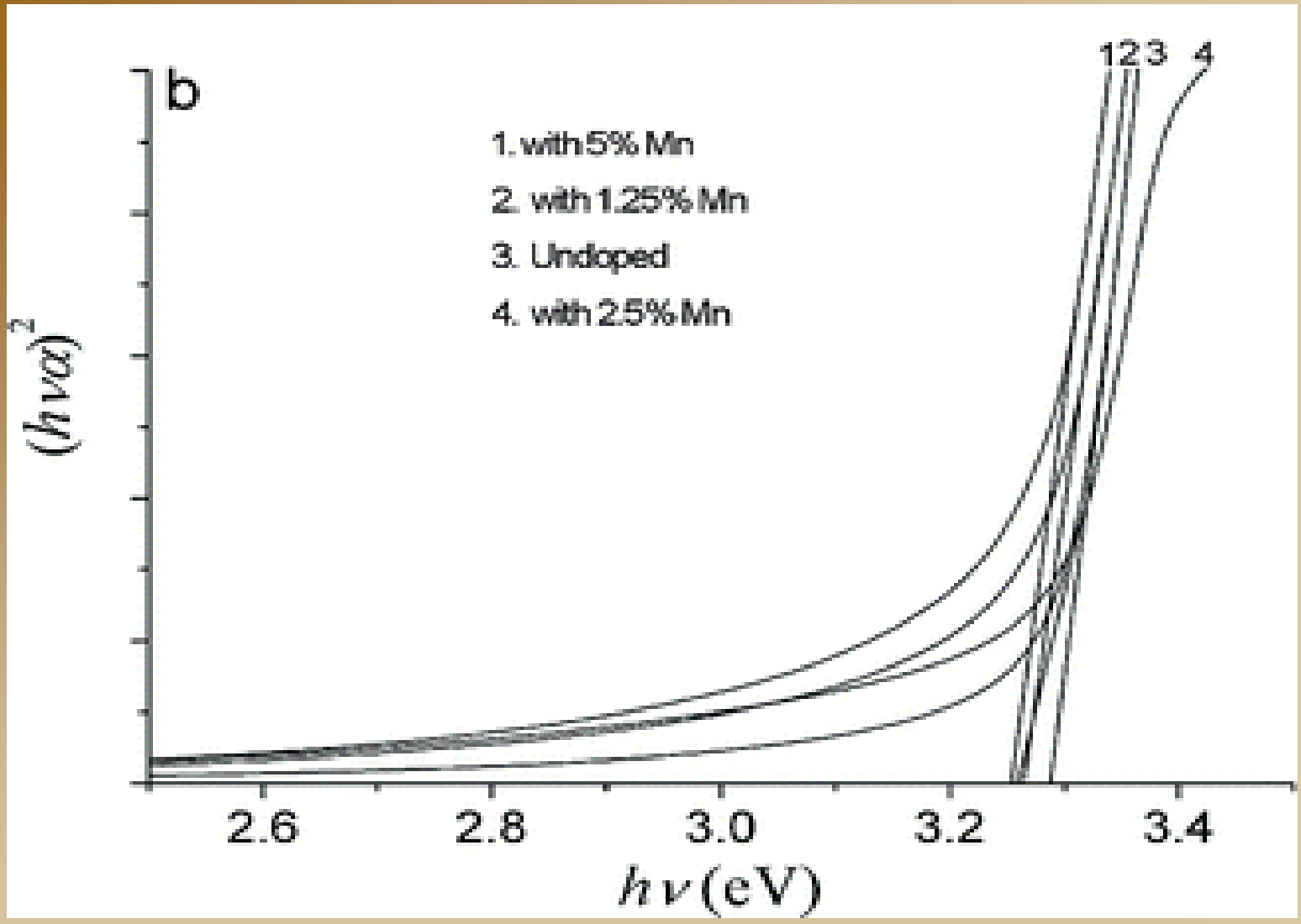
TEM and FESEM images of ZnO nanorods doped with different levels of Mn: and. In all cases, the products are composed of uniform nanorods, like that of undoped ZnO.



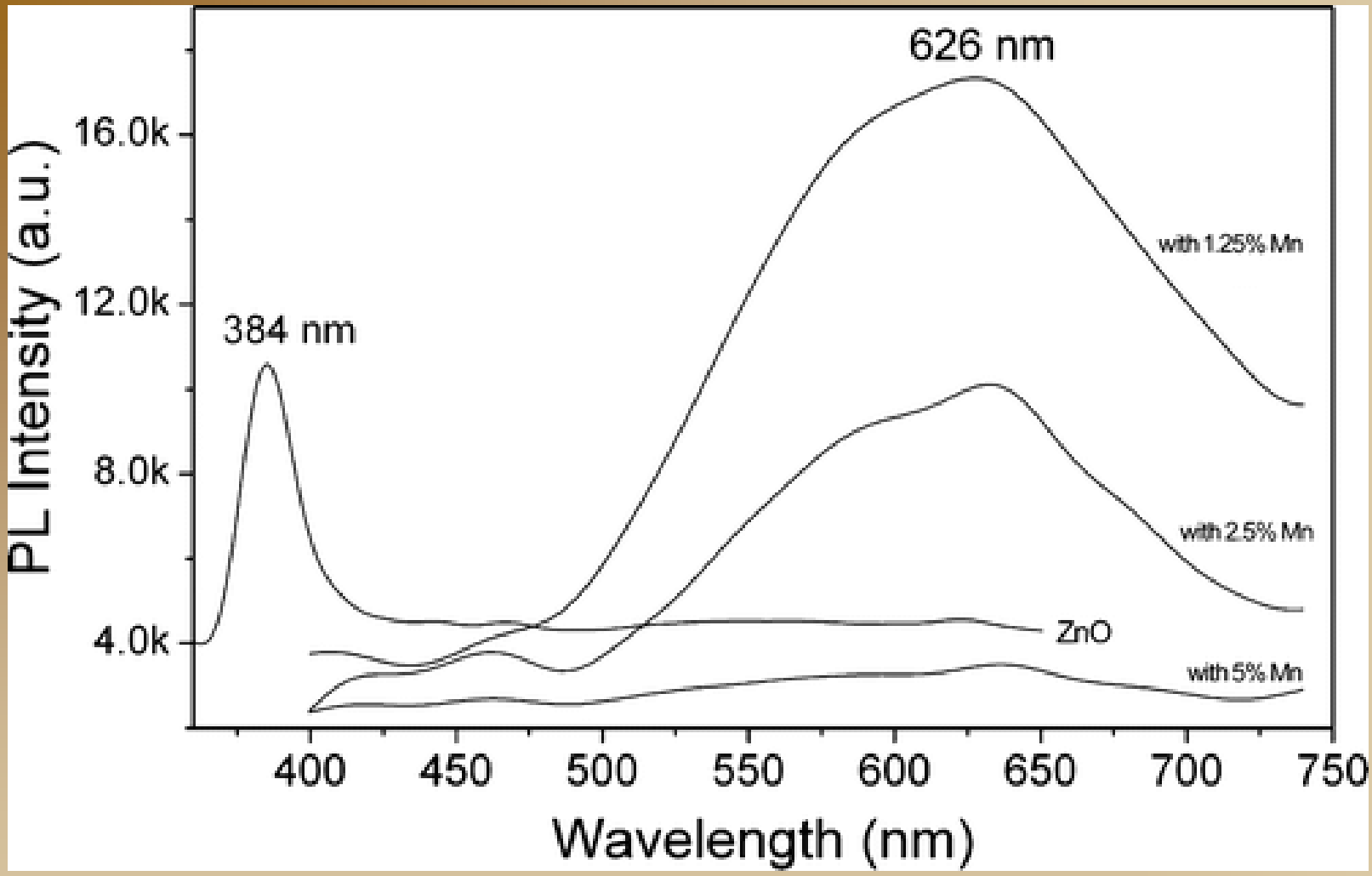
(e,f) with (g) Representative HRTEM image of ZnO nanorods doped with Mn. The arrows indicate the area destructed. (h) Corresponding SAED pattern.



Absorption spectra of undoped ZnO nanorods and those doped with different levels of Mn.



Plots of (αhv)2 against hv of undoped and Mn-doped ZnO nanorods (derived from above figure. The samples for UV−vis absorption measurements were prepared through dispersing the colloids into absolute alcohol.



PL spectra of undoped ZnO nanorods and those doped with different levels of Mn (excitation wavelength 375 nm). The samples for PL measurements were the dry solids.

Summary

- Synthesized colloidal undoped ZnO nanorods and Mn-doped ZnO nanorods in a gram scale at low temperature via the decomposition of Zn and Mn precursors in the methanol solution of potassium hydroxide.

- The substitution of parts of lattice Zn of ZnO by Mn^{2+} ions is confirmed by XRD and XPS techniques.

- The nanorods are well crystalline and have a narrow size distribution.

- Their surfaces are surrounded by large amounts of hydroxyl groups, which results in their good solubility and dispersivity in water and alcohol.

- The concentration of Mn^{2+} ions in the products can be controlled at the level of 1.25%, 2.5%, and 5% (in molar %), respectively.

Thank You