Supporting information

Fabricating β-cyclodextrin based pH-responsive nanotheranostics as a programmable polymeric nanocapsule for simultaneous diagnosis and therapy

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Fabrication of Fe_3O_4 and Fe_2O_3 nanoparticles

Fe_3O_4 nanoparticles were synthesized by co-precipitation method and then were converted to the γ-Fe_2O_3 nanoparticles by the aim of diluted HNO_3. FE-SEM result of the Fe_3O_4 nanoparticles revealed that these nanoparticles had spherical shape with 15.5±0.4 nm size (Figure S1).

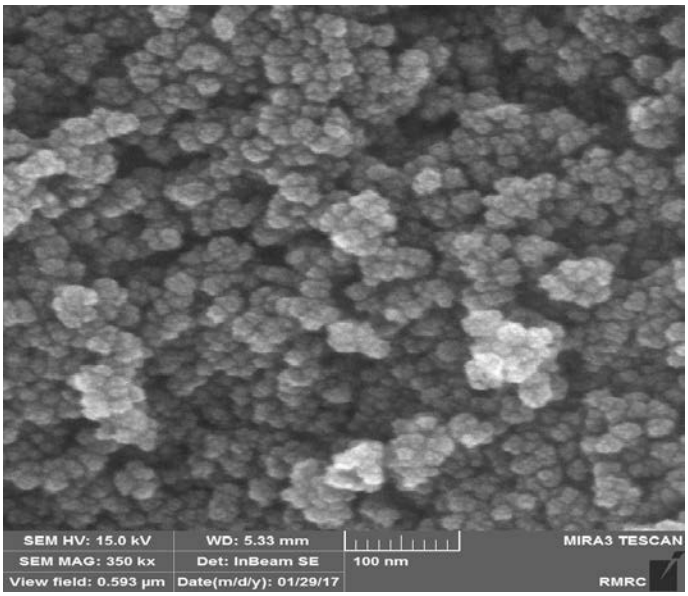

Figure S1. FE-SEM image of Fe_3O_4 nanoparticles.

Difference between FTIR spectrums of two nanoparticles were shown in Figure S2. Appearance of RNO_2 peak at around 1380 cm^{-1} and also two Fe-O peaks at 550-700 cm^{-1} in the curve of γ-Fe_2O_3 nanoparticles were two main differences that revealed the production of γ-Fe_2O_3.

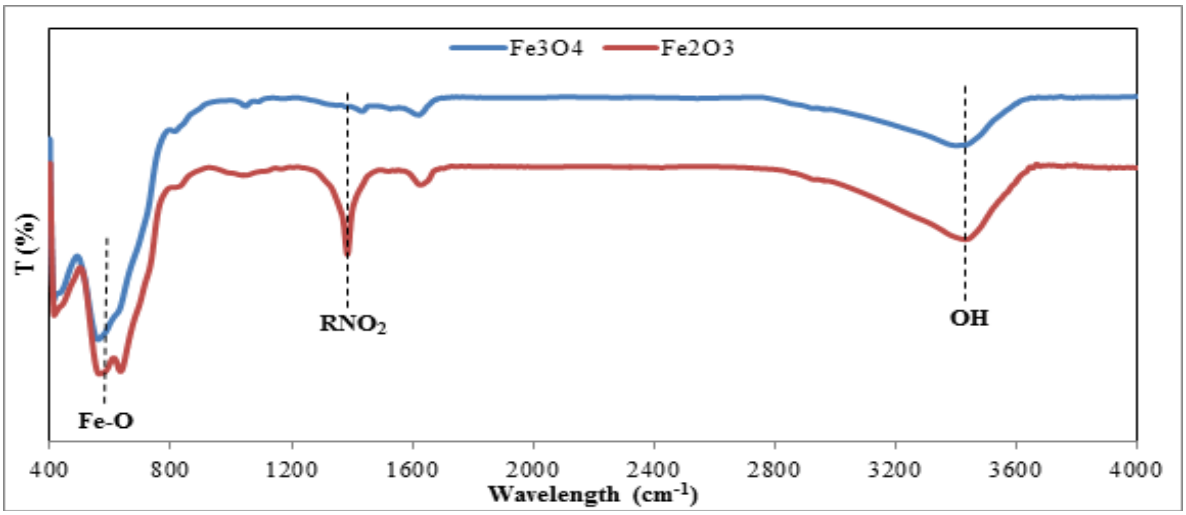

Figure S2. FTIR spectrum of Fe_3O_4 and γ-Fe_2O_3 nanoparticles.

In Figure S3, the XRD results of Fe_3O_4 and Fe_2O_3 nanoparticles were shown. In fact, there were no significant differences between the spectrum of Fe_3O_4 and Fe_2O_3 nanoparticles except two peaks at around 28˚ and 31˚ in the Fe_2O_3 spectrum which were indexed as (210) and (211), respectively (according to the JCPDS Card No. 019-0629 and JCPDS Card No. 39-1346 respectively) [1].

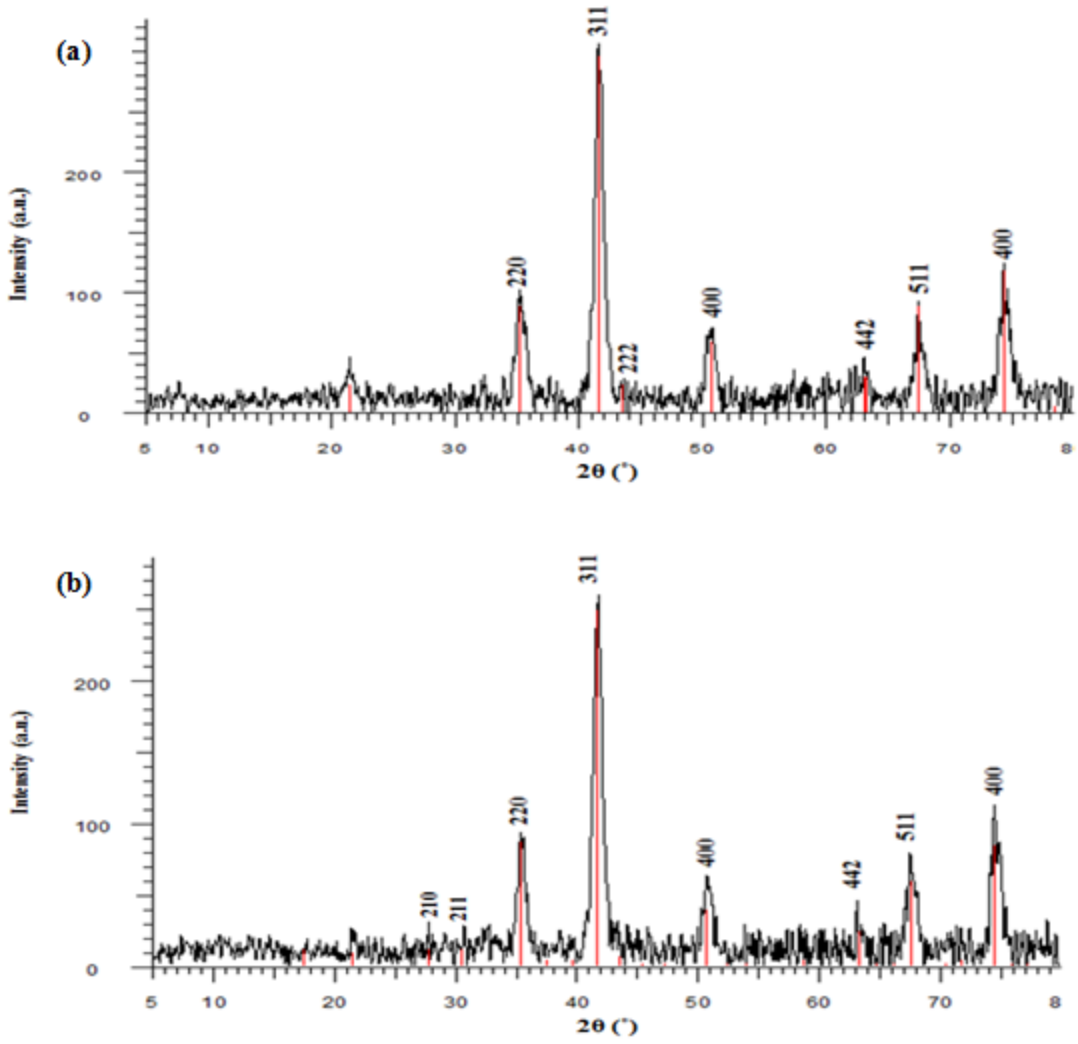

Figure S3. XRD results of a) Fe_3O_4 and b) γ-Fe_2O_3 nanoparticles.

Preparation of thiolated βCD

In order to prepare the first layer of the nanocapsule, it was necessary to thiolate the cyclodextrin monomers. This was done in a two-step process: tosylation of βCD, and exchanging the tosyle group with thiol group. Occurrence of tosylation process was confirmed by FTIR analysis. As it is clear in Figure S4, the emergance of the SO_2 peak in the spectrum of Tos-βCD in comparison with the βCD could be considered as an evidence that confirm this reaction.

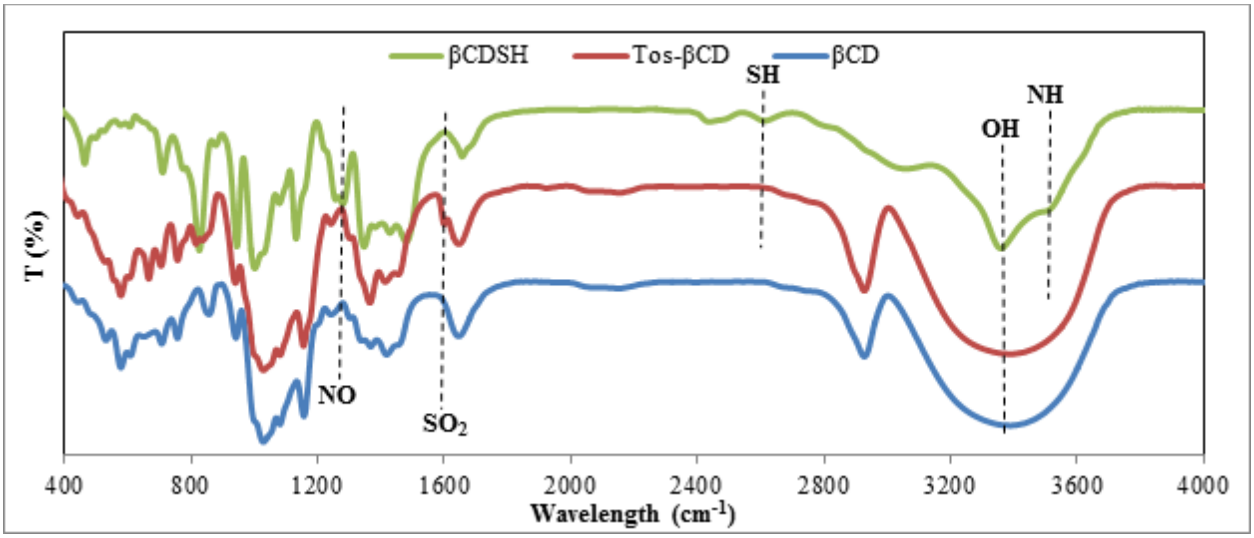

Figure S4. FTIR results of βCD, Tos-βCD and βCDSH.

The thiolation reaction was performed by the aim of cystamine dehydrochloride, in which the amine group of cystamine was attached to the βCD by removing the tosyl group. The appearance of NH, SH, and NO peaks at around 3400, 2600 and 1230 cm^{-1} as well as disappearance of tosyl peak in the spectrum of βCDSH were the most important findings that confirmed the correct formation of βCDSH.

Synthesis of PAA-SDN

After preparation of PAA-SDN polymeric layer, it was characterized with FTIR and 1H-NMR (in DMSO). The appearance of amid bond in FTIR (1690 cm^{-1}) and NMR (7.9 ppm) along with the elimination of the carboxylic acid peak (12ppm) of PAA in ^{1}H-NMR spectrum of PAA-SDN, revealed the formation of this layer (Figure S5).

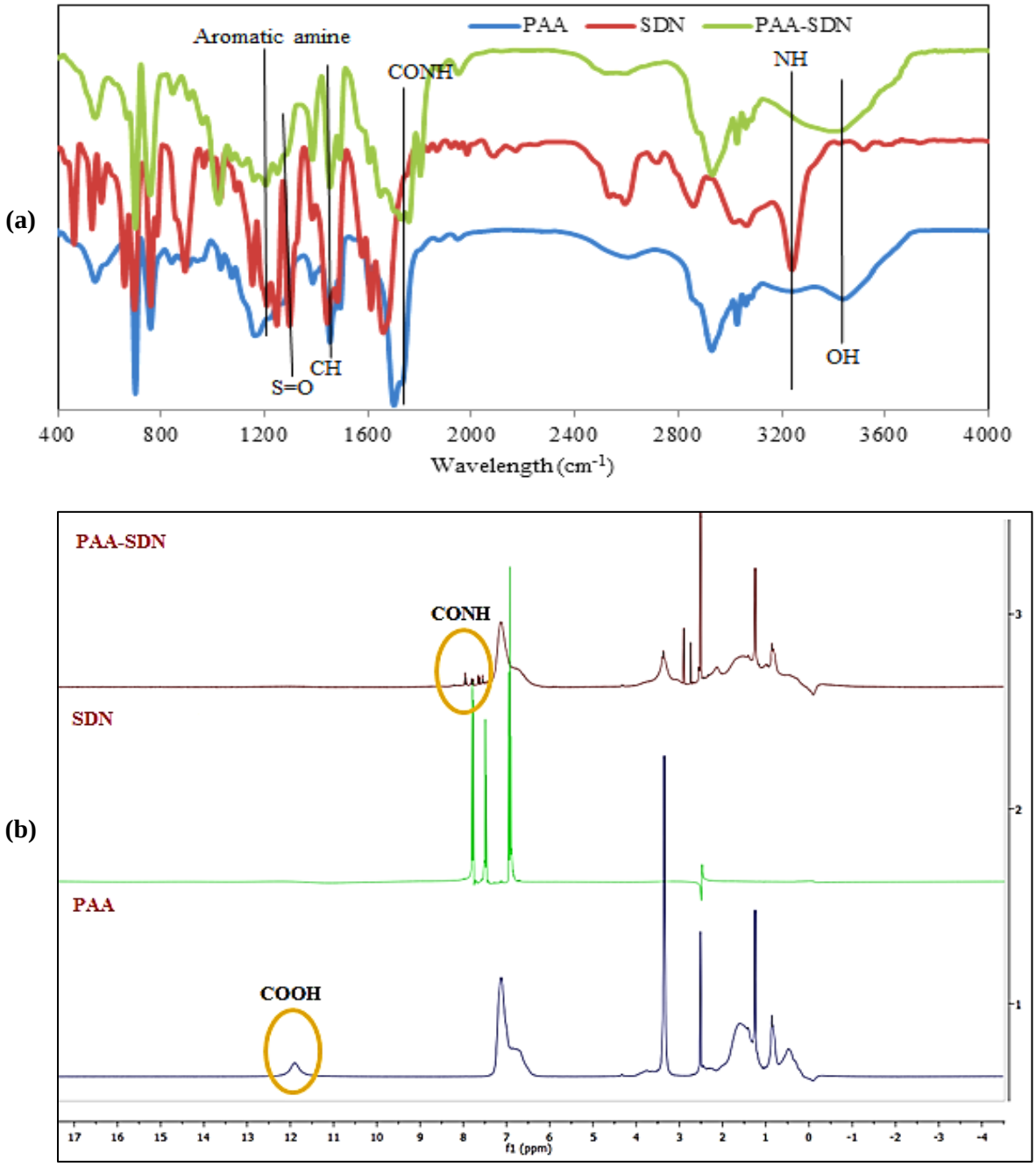

Figure S5. a) FTIR and b) ^{1}H-NMR results of PAA, SDN and PAA-SDN.

Preparation of PEI-βCD

In the third polymeric layer of this nanocapsule, molecules of βCD were attached to the linear PEI with molecular weight of 2500 Dalton. For this reaction, cyclodextrins were derivertized by the attachment of tosyl group acting as a suitable leaving group while

facilitating the attachment of βCD to PEI. In Figure S6 (a, b) the FTIR and ^{1}H-NMR (in D_2O) results of the third layer are shown. Based on the results of FTIR, appearance of amid bond at around 1690 cm^{-1} in the spectrum of PEI-βCD with the absence of NH and SO_2 peaks, revealed the preparation of the third polymer layer. This was further approved by the results of 1H-NMR (the characteristic peak at around 3.3 ppm). Based on the results of ^{1}H-NMR the mole ratio of βCD attached to nitrogen groups of the polymer was calculated at about 1:2.

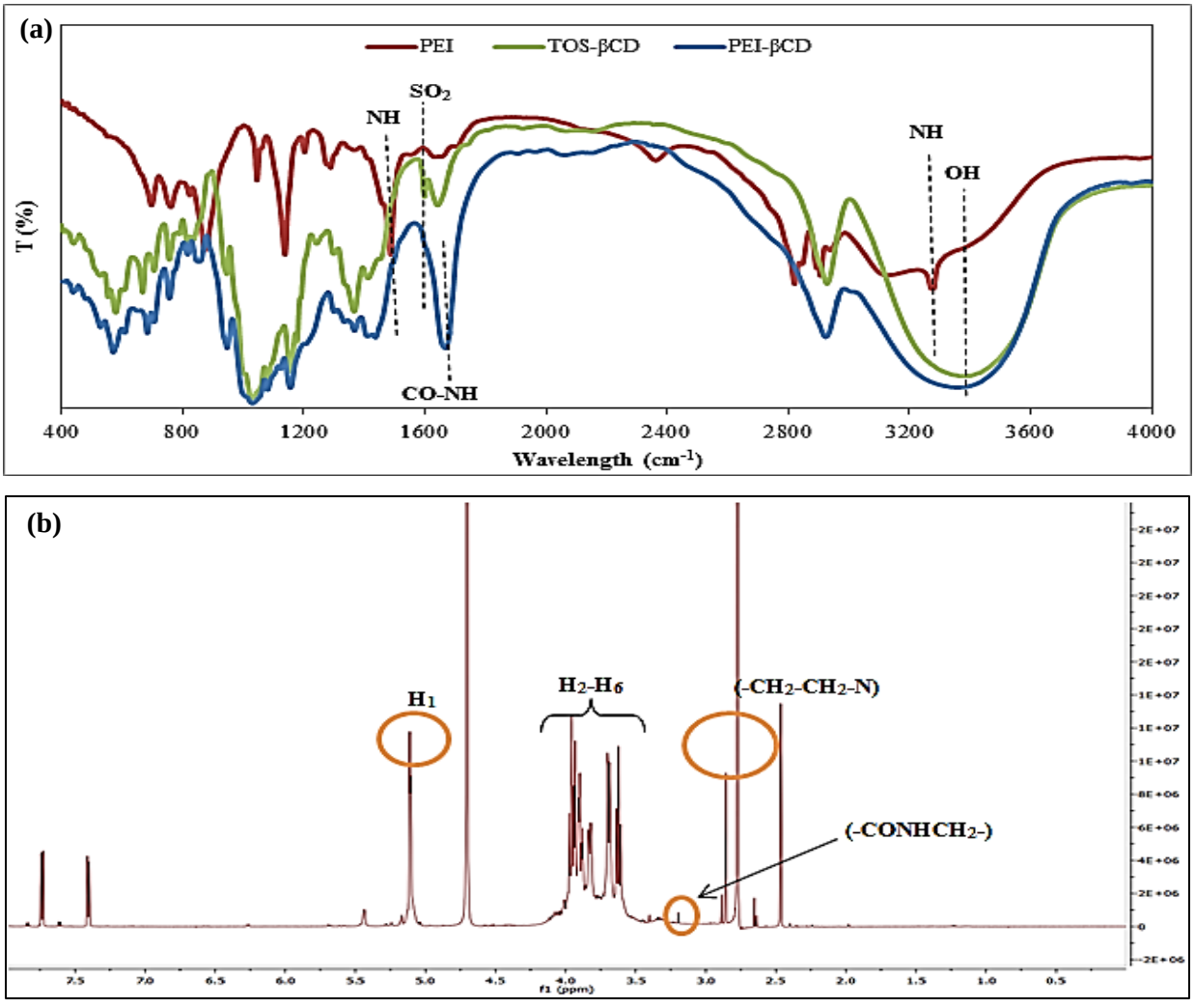

Figure S6. A) FTIR PEI, βCD, PEI-βCD and b) ^{1}H-NMR results of PEI-βCD.

References

[1] W. Kim, C.-Y. Suh, S.-W. Cho, K.-M. Roh, H. Kwon, K. Song, I.-J. Shon, A new method for the identification and quantification of magnetite–maghemite mixture using conventional X-ray diffraction technique, Talanta, 94 (2012) 348-352.