# Electronic Supplementary Information

# Superparamagnetic cobalt ferrite nanoparticles synthesized by gamma irradiation

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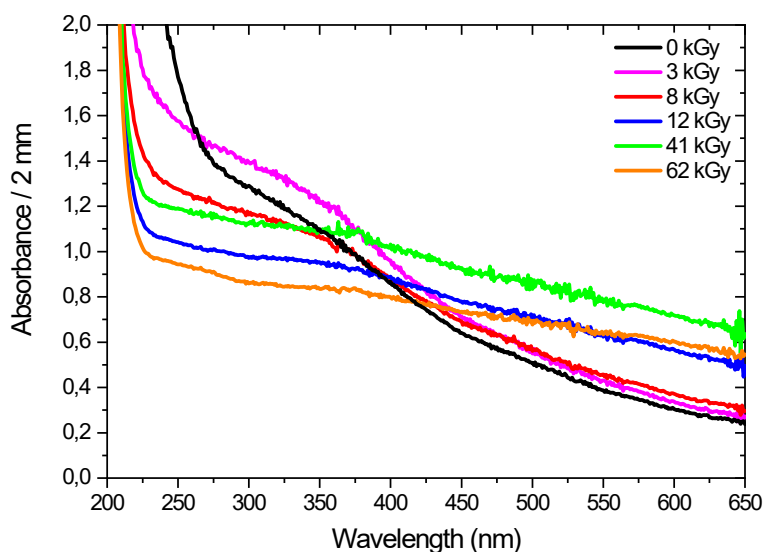
**Figure SI1.** Optical absorption spectra at various γ-doses of a solution containing $4 \times 10^{-3}$ mol $L^{-1}$ iron (III) chloride hexahydrate ($FeCl_3$, $6H_2O$), $2 \times 10^{-3}$ mol $L^{-1}$ cobalt (II) chloride hexahydrate ($CoCl_2$, $6H_2O$) $10^{-3}$ mol $L^{-1}$ PVP, and 0.13 mol $L^{-1}$ isopropanol. The pH of solution is ≈ 11.8.
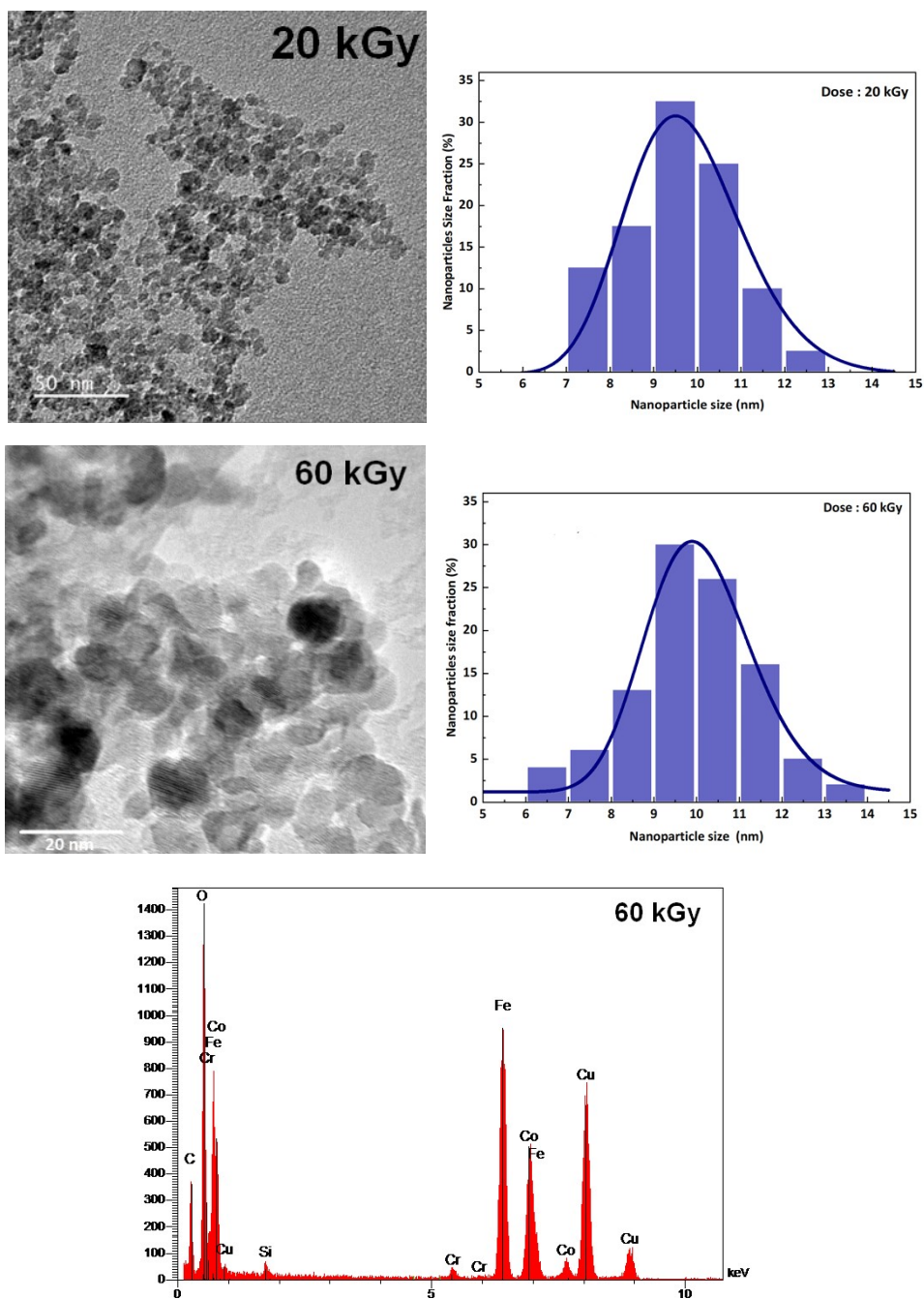
**Figure SI2.** Top: HRTEM images and size distribution of CoFe$_2$O$_4$ NPs radiation-induced at 20 kGy (D = 9.7 ± 1.0 nm). Middle : HRTEM images and size distribution of CoFe$_2$O$_4$ NPs radiation-induced at 60 kGy (D = 10.1 ± 1.5 nm). Bottom: EDS spectrum of CoFe$_2$O$_4$ at 60 kGy.
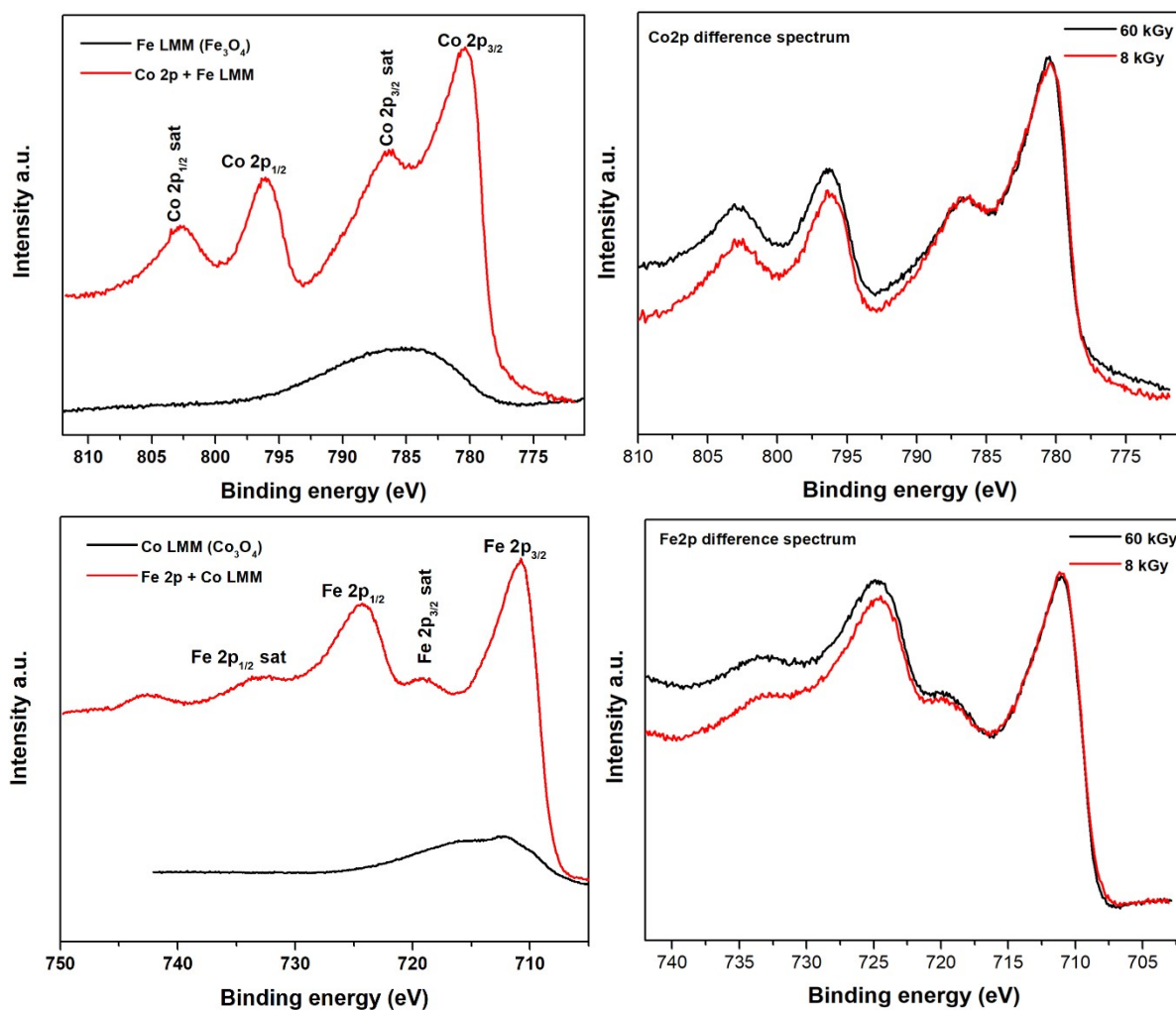
**Figure SI3.** The Fe 2p and Co 2p core-level spectra together with the interfering Auger signals (left) and a superposition of Fe2p and Co2p difference spectra obtained for samples irradiated at 8 kGy and 60 kGy (right). Fe LMM was measured on a reference sample of $Fe_3O_4$ and Co LMM on a reference $Co_3O_4$.
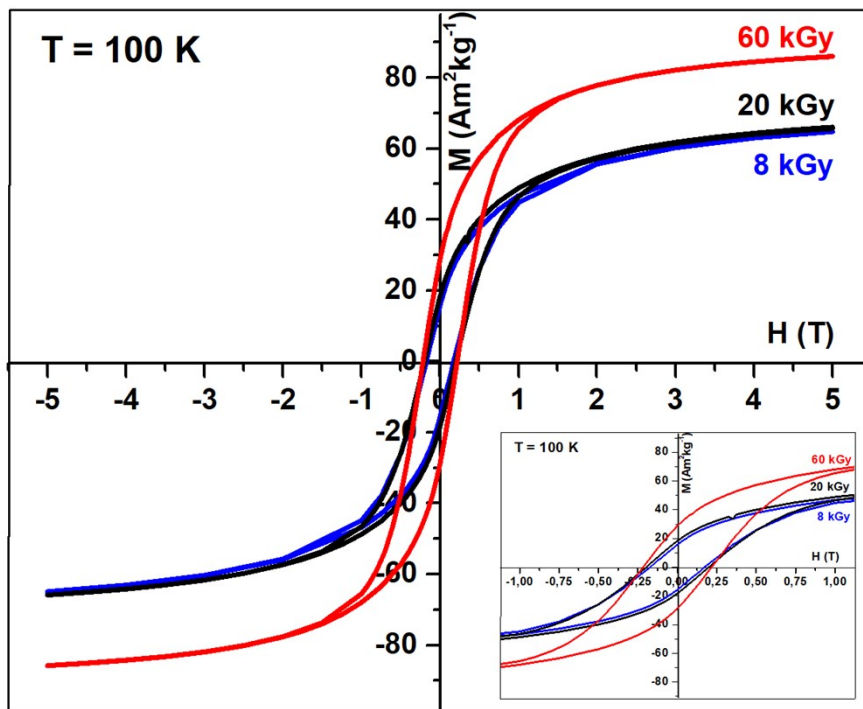
**Figure SI4.** Hysteresis loops of the magnetization (M) versus the magnetic field (H), measured at T = 100 K, of CoFe$_2$O$_4$ nanoparticles formed at the doses 8, 20 and 60 kGy. Right inset: magnification of the low field region.

**Table SI1.** Literature data on the synthesis and properties of cobalt ferrite CoFe$_2$O$_4$ nanoparticles.

| Authors | Method | Temperature of synthesis or treatment (°C) | Size D (nm) | Magnetic properties Ms (Am$^2$ kg$^{-1}$) | Reference |
|---|---|---|---|---|---|
| Mooney et al. 2004 | Reduction by alkalide in ether | Annealing at 200 - 1000 | 3 - 30 | 75 | 22 |
| Herrera et al. 2013 | Thermal decomposition | 325 | 5 - 12 | 10 - 50 | 64 |
| Bohara et al. 2014 | High thermal decomposition | 100 - 210 | 7 | 38 | 20 |
| Gaudisson et al. 2014 | Reduction by boiling polyols (EG, PEG) | Boiling point | 6 - 11 | 48 - 71 | 21 |
| Paramasivanet al. 2016 | Hydrothemal (PVP) | 200, then annealing at 400, 500,600 | 21 - 33 | 57 - 41 | SI[1] |
| Li et al. 2016 | Organic process (oleic acid, oleylamine, tetradecanediol, and benzyl ether). | 110 - 295 | 6 - 8 | 74 - 80 | 54 |
| Raut et al. 2015 | Sol-gel auto-combustion, annealing then Irradiation | 70 – 110, then annealing at 600 | 47 - 50 | 65 - 81 | 16 |
| Raut et al. 2016 | Sol-gel auto-combustion, then Irradiation | 70 – 110, then annealing at 600 | 52 - 59 | 65 - 84 | 60 |
| Angotzi et al. 2017 | Solvothermal seed-mediated growth | 200 | 8 - 12 | - | 17 |
| Zhang et al. 2017 | Thermal decomposition | 326 | 4 | 30 | 19 |
| Shams et al. 2018 | Coprecipitation | 60 | 8 | 50 | 17 |
| Darwish et al. 2019 | Coprecipitation | 60 | 8 | 50 - 60 | 62 |
| Gurgel et al. 2019 | Microwave-assisted hydrothermal | 40 | 6 - 15 | 54 - 65 | SI[2] |
| Kumar et al. 2020 | Coprecipitation | Annealing at 300 - 900 | 10 - 40 | 37 - 71 | 63 |
| Palade et al. 2020 | Hydrothermal pH 7 - 9 | 200 | 7.8 - 9.6 | 37.9 - 67.2 | 16 |
| Shanmugam et al. 2020 | Reduction by boiling glycol | Boiling point | 7.8 | 41 | SI[3] |

## References

1.  P. Paramasivan and P. Venkatesh, *J. Supercond. Nov. Magn.*, 2016, **29**, 2805-2811.
2.  A. L. Gurgel, A. E. Martinelli, O. L. de Aquino Conceição, M. M. Xavier Jr, M. A. M. Torres and D. M. de Araújo Melo, *J. Alloys Compd.*, 2019, **799**, 36-42.
3.  S. Shanmugam and B. Subramanian, *Mater. Sci. Eng. B.*, 2020, **252**, 114451.