Using chemical coprecipitation method to prepare magnetite magnetic fluids and explore its applications in hyperthermia

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In recent years, researches of hyperthermia have been widely conducted. One of the focuses is magnetic fluid hyperthermia (MFH), which is to place the magnetic fluid in alternating magnetic fluid and to increase the temperature of local tumor to 41-46℃ for eliminating tumor cells[1]. In this study, the chemical coprecipitation method was employed for magnetic nanoparticles and then the formula of SAR was to evaluate its capability in converting the energy into heat per time and mass[3]. As a result, magnetic nanoparticles have been an important factor in determining the efficiency of hyperthermia.

Eleven different kinds of parameters, including the preparation time (0.5hr, 1hr, 1.5hr, 2hr, 2.5hr, 3hr etc.), temperature (30℃, 60℃, 70℃, 80℃, 90℃, 100℃etc.), pH(4, 10, 12 etc.), different ratios of iron salts (Fe^{2+} : Fe^{3+} = 1:1, 1:1.5, 1:2, 1:2.5, 1:3, 1:3.5, 1:4 etc.), different alkaline media (NH_4OH and NaOH), different concentration (1g/ml, 7 g/ml, 14 g/ml, 28 g/ml, 50 g/ml etc.), different drying time (12hr and 24hr) and in comparison with Fe^{2+}:Fe^{3+}=1:1~1:4; different shaking time (0.5min、1 min、5 min、10 min、15 min etc.) and in comparison with Fe^{2+}:Fe^{3+}=1:1 and 1:2. The samples which are well-prepared in the magnetic fluid (75kHz) adjusted the power of electric current (125A, 200A, 300A, 400A, 500A, 600A etc.). After the repetitively heating the same sample, and XRD spectra, the maganetite of the sample was identified by its reaction. Finally, all of the best parameters from samples were in comparison to the commercial magnetic nanoparticles (< 50nm, Sigma Aldrich).

The SAR of pH=10 and 12 both were higher than that of pH=4, and there is no distinct difference between pH=10 and 12 (p=0.4229). In the preparation time, when the temperature reached 90℃ and 100℃, the SAR wass higher than other samples under different temperatures, and showed no distinct difference (p=0.4163). Moreover, we also concluded from the study that the SAR in different ratios of magnet. 1:1, 1:1.5, 1:2, are higher than that in others, and there is no distinct difference among the three of them [1:1 and 1:1.5(p=0.3683), 1:1 and 1:2(p=0.4742), 1:1.5 and 1:2(p=0.4269)].

Furthermore, the SAR from the sample of NH_4OH was higher than other sample of NaOH, and both of them showed distinct differences (p=0.001407). The SAR from the samples under 3 hours of preparation time was higher than others, and showed distinct differences from all the other samples. Even though the SAR from the sample of 1g/ml concentration was higher than others, it took more time for it to reach the temperature for hyperthermia. Therefore, we chose to use the sample of 50g/ml concentration, which can reach the temperature for hyperthermia faster, comparatively. In the process of preparation, using the ferric salts from different brands, Mallinckrodt, Nihon Shiyaku, Sigma Aldrich showed no distinct difference (Mallinckrodt: Nihon Shiyaku, $p=0.1430$; Mallinckrodt: Nihon Shiyaku, $p=0.1620$; Nihon Shiyaku: Sigma Aldrich, $p=0.4029$).

Setting the shaking time to 0.5 min, both the SAR from the samples of 1:1.5 and 1:2 ratios were lower, comparing with other samples which showed no distinct difference. In the drying time, except that Fe^{2+}:Fe^{3+} was in the ratios of 1:2:5 and 1:3:5 and had its SAR increased after 24hr of drying, other samples no distinct difference. In adjusting the electric current of magnetic fluid, the SAR of the sample increased with the amplification of electric current. In the repeatedly heated samples, except that the SAR of Fe^{2+}:Fe^{3+} resulted in 1:3~1:3.5 and showed no distinct difference, the SAR of other samples declined drastically. As a result, the best parameter for preparation time is 3hr and pH=10, the best preparation temperature is 90 ℃, the best brand is the Fe^{2+}:Fe^{3+} = 1:1, 1:1.5, and 1:2 from Sigma Aldrich, the best proportion of concentration is 50g/ml, and the best shaking time was 1min every time before heating. In the end, comparing our samples (Fe^{2+}:Fe^{3+} is 1:1~1:2) with the commercial magnetic nanoparticles, they all showed distinct differences as the following, Commercial:1:1 ($p=0.0021$); Commercial:1:1.5 ($p=0.0001$); Commercial:1:2 ($p=0.0006$). There is no distinct difference in the sample of Fe^{2+}:Fe^{3+} as 1:1~1:2 (1:1 compares with 1:1.5, $p = 0.1061$; 1:1 compares with 1:2, $p = 0.1147$, 1:1.5 compares with 1:2, $p = 0.2659$). In the long run, the sample with dextran, and study their changes after heating will be under continuous observation.

Reference

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