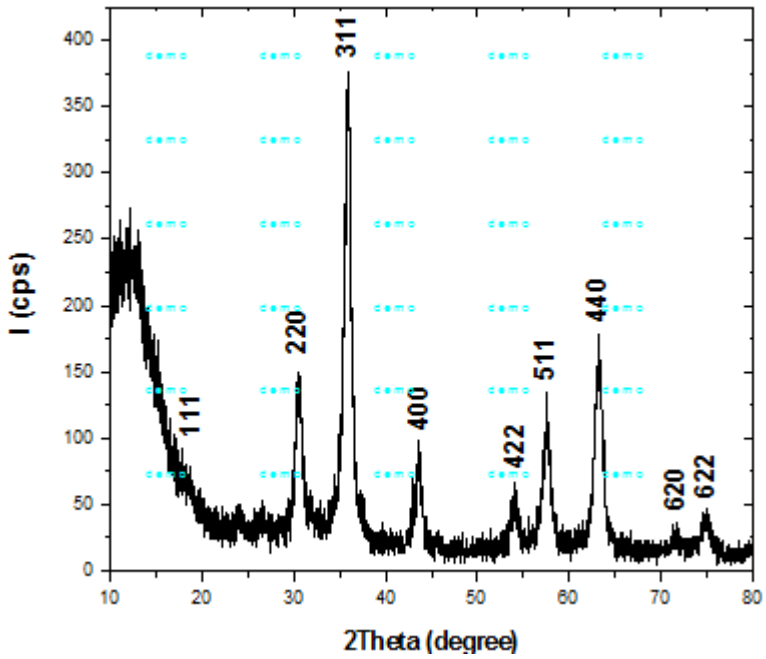

Figure 1: XRD for Fe_3O_4

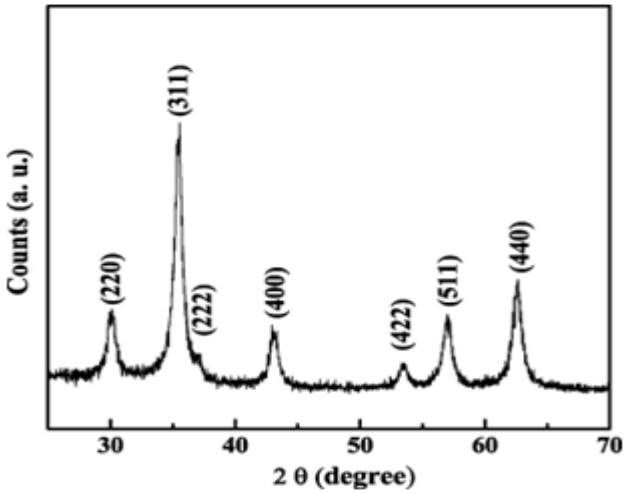

Figure 2: XRD for Fe_3O_4 [4]

Table 1: The parameters of the three strongest peaks

No	2 theta (deg.)	d (Å)	FWHM (deg.)	*t* nm	*hkl*	a(Å)
1	35.8583	2.50227	0.85940	9.80	2 1 1	8.299
2	63.1667	1.47077	0.92000	10.2	4 4 0	8.320
3	30.4993	2.92862	0.89470	9.30	2 2 0	8.283

To determine the prepared sample of Fe_3O_4size "t", the interplanar distance of the crystal "d_{hkl}" and the lattice parameter "a" from the XRD data, the peaks positions and the full width at half maximum of the three strongest peaks, shown in table1, are substituted in the Scherrer's formula (1) and Bragg's equation (2) are given by

$$t = \frac{K\lambda}{B\cos\theta} \qquad (1)$$

$$d_{hkl} = \frac{\lambda}{2\sin\theta} \quad ,, \quad d_{hkl} = \frac{a}{\sqrt{(h^2+k^2+l^2)}} \qquad (2)$$

Where; t is the thickness of the crystallite, a is the lattice parameter, *hkl* are Millar's indices, d_{khl} is the interplanar distance of the crystal, K~ 0.9 is constant depend on the crystallite shape, λ = 1.456 Å is x-ray wavelength of the Cu target, B is full width at half maximum (FWHM) and θ_B is Bragg's angle [2, 5, 6].

The XRD patterns indexing of the prepared Fe_3O_4showed that this sample is cubic with average lattice parameter is 8.3 Å and the average size is 9.8 nm. The crystal structure, the size and the lattice parameter in good agreement with published data fig.2. Such a small size indicates that the Fe_3O_4 sample is the magnetic nanoparticles MNPs [4].

3.2The SAR of Fe_3O_4 MNPs suspension

To determine the heating rate $\Delta T/\Delta t$ and specific absorption rate SAR value of the Fe_3O_4 MNPs, a suspension of 1ml de-ionizing (DI) water + 1mg Fe_3O_4 MNPs was prepared.

First, 1 ml of DI water was exposed to the magnetic induction and no change on the temperature is noted. Then, 1 mg of Fe_3O_4 MNPs was added to 1ml DI water and exposed to the same magnetic induction; the temperature is seen to increase with the time. After 35 minutes the temperature reached 46^{o}C and remained constant up to 60 minutes exposure to the magnetic induction heating. The temperature no longer changed over time when it reached to a certain value because the heat generated by the absorbed electromagnetic energy of Fe_3O_4 and the heat released towards the environment were equal that is shown in fig.3 [7, 8].

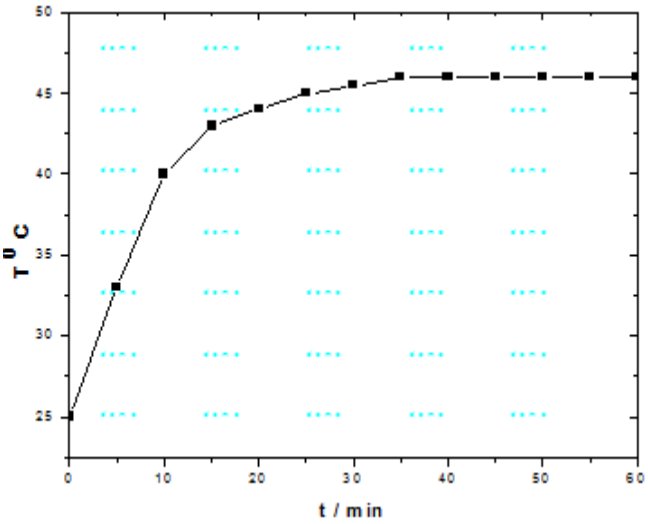

Figure 3: Fe_3O_4 heating rate

The SAR value can be calculated by the following equation

$$SAR = C \frac{\Delta T}{\Delta t} \frac{1}{m_{ferrite}} \quad (3)$$

Where; C= 4.185 J g $^{-1}$K $^{-1}$ is the sample specific heat capacity which is calculated as a mass weighed mean value of magnetite and water. $\Delta T/\Delta t$ = 0.025 ^{o}C/ sec is the initial slope of the time dependent temperature curve, m $_{ferrite}$ =1 mg is the ferrite content per mg of the sample tube [8].

There are as good as the linear relations in the first rising of the temperature fig.3. We used the linear relation in 0 – 10 minutes intervals for calculating the SAR values of the samples Fe_3O_4MNPs by equation (3). We find that the SAR value equal105 W. g $^{-1}$.

4. Conclusions

The average size and the lattice parameter of the Fe_3O_4 magnetic nanoparticles sample MNPs was prepared by co precipitation method were estimated to be 9.8 nm and 8.3 Å respectively.

The maximum temperature was 46^{o}C and the needed time to reach this temperature was 35 min with the concentration of 1.0 mg Fe_3O_4/ 1ml of deionizing water. The temperature no longer changed over time when it reached to a certain value. The specific absorption rate SAR and the heating rate$\Delta T/\Delta t$ values of the Fe_3O_4 MNPs were founded to be105 W. g $^{-1}$and0.025^{o}C/ sec, these values indicating to use this sample in the magnetic hyperthermia treatment MHT.

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