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ORIGIN OF MAGNETISM STUDY ON SOME COMMERCIAL Fe_2O_3

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ABSTRACT

Six kinds of typical commercial Fe_2O_3 were sampled and divided into two groups A and B according to the magnetic measurement results. The samples of group A are of susceptibility about 10^{-4} and the specific saturation magnetization σ_s 0.2–0.3 $A.M^2/kg$, being consistent with the feature of antiferromagnetic $\alpha-Fe_2O_3$. While the samples of group B display strong magnetism with susceptibility 10^{-1}–10^{-2} and σ_s 1.7–12 $A.M^2/kg$. Mössbauer spectra of the samples were investigated at room temperature in an external magnetic field. It is suggested there is the $\gamma-Fe_2O_3$ phase in the group B according to the relative intensities of spectra $I(2,5)/I(3,4)$. This was proved by the Mössbauer spectra for the mixed samples A with $\gamma-Fe_2O_3$ at various contents and by measuring the dependence of specific saturation magnetization on temperature for the samples of group B.

Keywords: Mössbauer spectroscopy Fe_2O_3 Origin of magnetism

1 INTRODUCTION

As well known the quality of raw material Fe_2O_3, including impurity and activity, is important to ferrite manufacture. In our recent experiments it is found that some commercial Fe_2O_3 materials, which are suitable for ferrite manufacture, have strong magnetism in contradiction to the feature of antiferromagnetic material. The magnetic contents involved in the iron oxide raw materials had been studied by Raier fick[1] through measuring the specific saturation magnetization at various temperatures. To investigate the origin of magnetism on some commercial Fe_2O_3, not only the magnetic measurement, but also the Mössbauer measurement with the external magnetic field is carried out and the results are reported in this paper.

2 EXPERIMENTS

Six kinds of typical commercial Fe_2O_3 were sampled and divided into two groups according to the magnetic measurement results. The samples of group A have no strong magnetism and can not be attracted by the magnet. While the samples of group B display strong magnetism and can be attracted by the magnet. The specific magnetization σ_s and the susceptibility x were measured by the vibrating sample magnetometer. The phase compositions were analysed by the X-rays diffractometer ADP15. The Mössbauer spectra were taken out of the Mössbauer spectrometer AEM-50 at room temperature with applied magnetic field parallel (1.2 T) and perpendicular (1.5 T) to the gamma-rays direction.

3 RESULTS AND DISCUSSIONS

Table 1

Magnetic measurement results for Fe_2O_3 raw materials

No.	Purity (%)	σ_s (A.M^2/kg)	χ ($\times10^{-4}$)
A-1	99.99	0.232	3.07
A-2	99.83	0.296	8.92
A-3	99.55	0.310	4.95
B-1	99.99	12.060	1220
B-2	99.90	7.810	793
B-3	99.80	1.680	218

The magnetic measurement results are given in Table 1. It shows that the samples of group A are of susceptibility about 10^{-4} and the magnetization σ_s 0.2-0.3 A·M^2/kg, being consistent with the feature of antiferromagnetic $\alpha-Fe_2O_3$. The samples of group B display strong magnetism with susceptibility $10^{-1}-10^{-2}$ and σ_s 1.7-12 A.M^2/kg.

The origin of strong magnetism may be come from some magnetic substances involved in the $\alpha-Fe_2O_3$ matrix, such as Fe_3O_4 or $\gamma-Fe_2O_3$. While the X-rays diffraction results show that all of the Fe_2O_3 raw materials are $\alpha-Fe_2O_3$ and have no observable evidence of the other phases. Chemical analyses do not show any composition. The Mössbauer spectra of six Fe_2O_3 samples at zero field also indicate that there is no second Fe_3O_4 phase.

It is known that the intensity of the 2,5 lines corresponding to the nuclear transitions $\triangle I_z=0$ in the sextet is sensitive to the external magnetic field. As the field changes from zero to the parallel field (1.2 T) the relative intensity I_r [$I(2,5)/I(3,4)$] changes from 2 to 4 for $\alpha-Fe_2O_3$, from 2 to 0 for $\gamma-Fe_2O_3$, and as the field from zero to the perpendicular field (1.5 T) the I_r changes from 2 to 0 for $\alpha-Fe_2O_3$, from 2 to 4 for $\gamma-Fe_2O_3$[2]. The Mössbauer technique with external field provids a valuable tool for distinguishing the $\gamma-Fe_2O_3$ spectrum from the $\alpha-Fe_2O_3$ main spectrum. The spectra of sample B-1 at

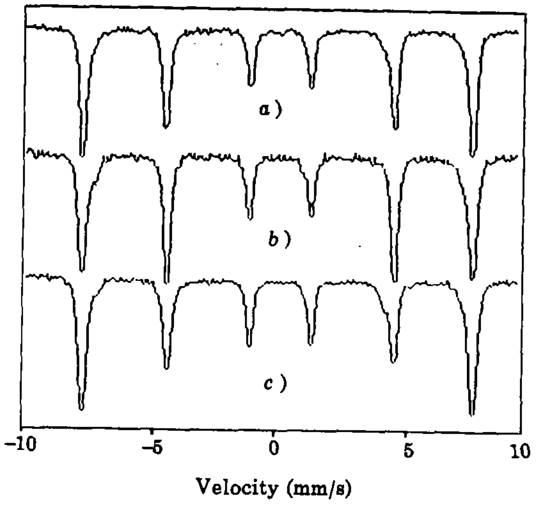

Fig.1 The Mossbauer spectra of sample B-1 at room temperature

a) $H=0$ b) $H_{\parallel}=1.2$ T c) $H_{\perp}=1.5$ T external field are shown on Fig.1.

The Mössbauer parameters of sample A-1 and B-1 for zerofield are listed in Table 2, and the relative intensities $I_r[I(2,5)/I(3,4)]$ in the external field for samples A-1 and B-1 are given in Table 3.

Table 2
Mössbauer parameters of Fe_2O_3 raw materials

No.	IS (mm/s)	QS (mm/s)	H_{hf} (T)	FWHM (mm/s)
A-1	0.40	-0.15	50.89	0.26
B-1	0.40	-0.09	51.36	0.29

Table 3
Relative intensity I_r [$I(2,5)/I(3/4)$]

No.	$H=0$	$H_{\parallel}$(1.2 T)	$H_{\perp}$ (1.5 T)
A-1	1.94	2.53	1.56
B-1	1.91	2.09	1.81

The fact, that the relative intensity values I_r for the sample A-1, 2.53 at the parallel field and 1.56 at the perpendicular field, are far from the expected values 4 and 0 for the $\alpha-Fe_2O_3$. This fact may be explained by the reason that the applied fields 1.2T and 1.5T are not strong enough. While its variation tendency is consistent with the feature of $\alpha-Fe_2O_3$. The differences between the value of I_r for sample A-1 and that for B-1 at the applied field are attributed to the contribution of the second $\gamma-Fe_2O_3$ phase.

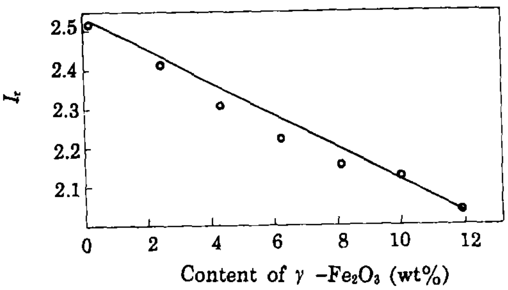

Fig.2 The relative intensity I_r vs the contents of $\gamma-Fe_2O_3$

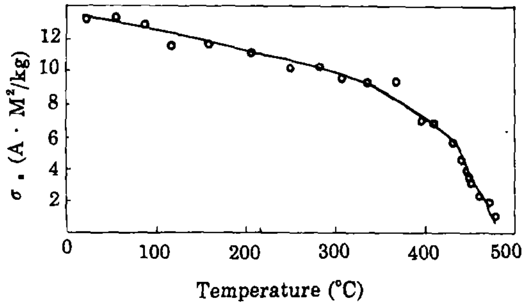

Fig.3 The σ_s vs the temperatures of sample B-1

Mössbauer spectra with applied parallel field for mixed samples A-1 with $\gamma-Fe_2O_3$ 0 wt% to 12 wt% were investigated. Fig.2 shows the relative intensity I_r vs the contents of $\gamma-Fe_2O_3$. It decreases gradually from 2.53 (with the $\gamma-Fe_2O_3$ 0 wt%) to 2.0 (with the $\gamma-Fe_2O_3$ 12 wt%). This behaviours are similar to that of the samples of group B. It demonstrates that the strong magnetism of group B Fe_2O_3 materials comes from the second $\gamma-Fe_2O_3$ phase involved in $\alpha-Fe_2O_3$ main phase but undetectable by the X-rays diffraction.

Finally the magnetic measurements for the samples of group B were carried out with heating samples gradually up to 500°C. Fig.3 shows the curve of σ_s vs the temperatures for sample B-1.

The measurement of σ_s as a function of temperature on sample B-1 reveals that at about 390 °C the magnetization σ_s drops down quickly, being in closest analogy to the behaviour of $\gamma-Fe_2O_3$ which transforms into $\alpha-Fe_2O_3$ at 400 °C in air.[3] This result gives further support to above conclusion. From the σ_s value of sample B-1 at room temperature and the known σ_s value for $\gamma-Fe_2O_3$ (81 A · M^2/kg), about 15 wt% $\gamma-Fe_2O_3$ content is estimated, that is close to the result of 12 wt% $\gamma-Fe_2O_3$ content in sample B-1 from the Fig.2 and the Table 3.

4 CONCLUSIONS

By means of the Mössbauer spectra with applied field, it is detected that the strong magnetism of some commercial Fe_2O_3 materials comes from the second $\gamma-Fe_2O_3$ phase involved in the $\alpha-Fe_2O_3$ main phase.

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