Magnetic Ordering of \( \text{\textmu}-\text{MnOs} \) alloys

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It has been known that pure \( \text{\textmu}-\text{Mn} \) has no long-range magnetic ordering down to the lowest temperatures [1]. In the \( \text{\textmu}-\text{Mn} \) alloys, the alloying transition elements are usually substituted for Mn atoms in 8c and/or 12d sites of the \( \text{\textmu}-\text{Mn} \) structure (P4132) [2], and the magnetic properties significantly depend on the substituted site of the elements. For example, in the \( \text{\textmu}-\text{MnFe}, \text{\textmu}-\text{MnCo} \) and \( \text{\textmu}-\text{MnNi} \) alloys where most of the additional atoms occupy the 8c site, the magnetism has been determined by NMR examination to be antiferromagnetic [3]. However, no experimental evidence for the long-range antiferromagnetic ordering has been reported in the previous neutron diffraction study [4]. We have investigated various physical properties of \( \text{\textmu}-\text{MnTM} \) (TM = Os, Ru and Ir) alloys because the TM can be substituted for a wide concentration range in the \( \text{\textmu}-\text{Mn} \), almost up to 40 at. %.

In the present investigations, we performed neutron powder diffraction (NPD) investigations for \( \text{\textmu}-\text{Mn1-xOsx} \) alloys with \( x = 0.06 \) and 0.25 in order to confirm the existence or absence of the magnetic ordering.

The alloys were prepared by arc melting and the obtained ingots were annealed at 1273 K and then quenched in ice water. The NPD experiments were carried out using the Kinken powder diffractometer, HERMES [5], of Institute for Materials Research (IMR), Tohoku University, installed in the JRR-3M reactor at the Japan Atomic Energy Agency (IAEA), where the wavelength was 0.182646 nm. The obtained NPD data were analyzed with the Rietveld method using RIETAN2000 program [6].

Figure 1 shows the NPD patterns measured at 8 K (a) and 200 K (b) and the difference of them (c) for \( x = 0.25 \). The diffraction pattern at 200 K can be simply indexed as the nuclear peak of the basic \( \text{\textmu}-\text{Mn} \) structure. It was confirmed by the Rietveld analysis that the obtained peaks are indexed as the \( \text{\textmu}-\text{Mn} \) structure with \( a = 0.6486 \) nm, and that the site occupancies of Mn atoms in the 8c and 12d sites are \( g = 0.37 \) and 0.93, respectively, i.e., most of the Os atoms occupy in the 8c site. On the other hand, many additional peaks are observed in the diffraction pattern at 8 K (a). According to our previous investigation, an anomaly in the thermo-magnetization curve has been observed around 160 K.

Figure 2 shows the temperature dependence for the intensity of a large magnetic peak for \( x = 0.25 \), indicated by an arrow in the Fig. 1 (c), is shown in Fig. 2. It is evident that the magnetic peak disappears at around 160 K almost coinciding with the temperature in which the anomaly was confirmed in the magnetic measurements. Therefore, it is concluded that the anomaly is attributed to the Neel temperature.

The anomaly in the magnetic diffraction pattern, it would be thought that the magnetic structure is classified as a non-collinear-type in antiferromagnetic structures. The detailed magnetic structure is now under consideration.

Figure 3 shows the NPD patterns at 4 K (a) and 50 K (b) and the difference of them (c) for \( x = 0.06 \). It was determined by the Rietveld analysis that the obtained peaks are indexed as the \( \text{\textmu}-\text{Mn} \) structure with \( a = 0.6315 \) nm, and that the 8c and 12d sites are occupied by the Mn atoms with \( g = 0.91 \) and 0.97, respectively. No magnetic peak is observed in the diffraction patterns obtained at 4 K (a), although an anomaly in the magnetic measurements was detected at around 40 K. These results are similar to that of the \( \text{\textmu}-\text{MnCo} \) alloy [4].

According to the theoretical calculations,
the magnetic moments for a Mn atom in the 8c and 12d sites are completely different and evaluated to be about 0.2 and 1.25 mB/Mn-atom, respectively [7]. The absence of the magnetic ordering of the pure $\alpha$-Mn alloy is thought to be caused by the geometrical frustration of the Mn atoms in the 12d site forming a triangular lattice [8]. It would be concluded that the lattice expansion and/or the distortion of the triangular lattice given by the substituted alloys in the 8c site bring about the long-range antiferromagnetic ordering.

References