

## **Thermal and spectroscopic characterization of the products obtained from the reaction between Mn-Carbonate and Ammonium Dichromate at different temperatures**

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Pure and mixed Mn-Cr oxides were prepared from the reaction between manganese carbonate and ammonium dichromate with molar ratios of 3:1, 1:1 and 1:3 with respect to  $Mn_2O_3:Cr_2O_3$ . Thermal decomposition for each of the mixture and the pure compound was studied using DTA and TG techniques. Pure and mixed salts were thermally treated at temperatures of 250°C, 500°C, 750°C and 1000°C and characterized by means of x-ray diffraction analysis and IR absorption spectroscopy.

The results obtained revealed that the thermal treatment of mixtures at 250°C produced a well crystalline  $MnCO_3$  and/or Cr-oxide phases depending on the composition of the mixture. At 500°C, poorly crystalline  $Mn_2O_3$ ,  $Cr_2O_3$  and amorphous manganese chromate intermediates were detected. Further increase in temperature of treatment was accompanied by the formation of  $Mn_{3-x}Cr_xO_4$  compound in all mixtures. This compound decomposes at temperatures just lower than 700°C to form crystalline phase of  $Mn_3O_4$  and  $Cr_2O_3$ .

## Introduction

Many binary oxides are widely used in catalysis(1-4). These binary systems were found to be more catalytically active than their separated oxide components(5,6). In catalysis, it is well known that the activity of oxide catalysts depends on many factors, such as methods of preparation, calcination conditions and the interaction occurring between the different components of the catalyst, the latter is a very important factor and many investigations are cited in the literature concerning this subject(7-9).

In the present investigation, we studied the effect of temperature on the interaction between manganese and chromium salts in order to characterize the different products obtained at various temperatures of treatment. The techniques employed in this work were DTA, X-ray diffraction spectroscopy and IR absorption spectroscopy.

## Experimental

The starting materials used in this investigation were pure ammonium dichromate and manganese carbonate from BDH grade. Mixtures of molar ratios 3:1 (I), 1:1 (II) and 1:3 (III) with respect to  $\text{Cr}_2\text{O}_3:\text{Mn}_2\text{O}_3$  were prepared by mixing and grinding the salts. Each one of the pure ammonium dichromate, manganese carbonate and their mixtures I, II and III was heated at temperatures of  $250^\circ$ ,  $500^\circ$ ,  $750^\circ$ , or  $1000^\circ\text{C}$  for 4 hours.

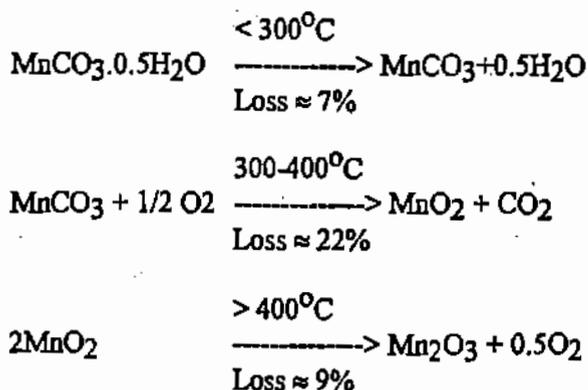
Thermal analysis for each of  $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$  and Mn-carbonate was carried out using DTA and TG unit of the NETZSCH Gerätebau simultaneous thermal analysis system (STA 409, 6.223). The rate of heating was  $10^\circ\text{C min}^{-1}$ .

The X-ray diffractograms of the samples were taken on a diffractometer Philips (Holland) with a scintillation counter and plus height analysis at 35Kv, 14 mA using Co-target radiation. The spectra were scanned at rate of  $2^\circ\text{min}^{-1}$  in  $2\theta$ .

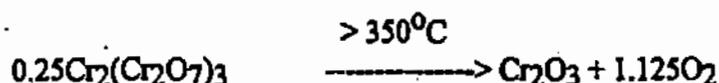
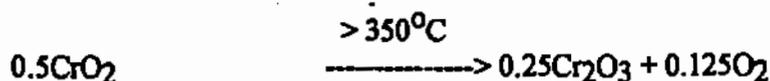
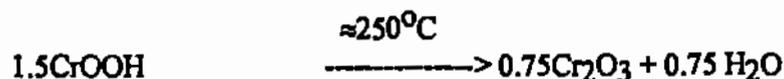
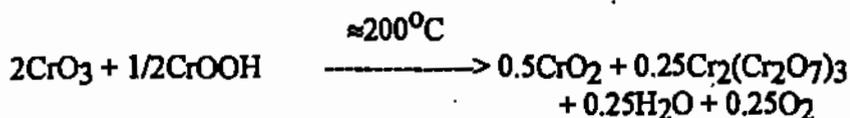
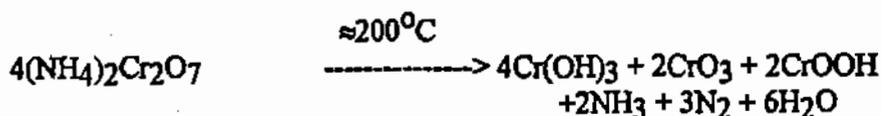
IR spectra of the samples were recorded on a Beckman infrared spectrophotometric unit using the KBr disc technique.

## Result and Discussion:

The thermal analysis diagrams for pure manganese carbonate, Fig. 1, show that the compound starts to decompose by losing the dehydration water at temperature range of 100-250°C. The weighing loss  $\approx 7\%$  occurring at temperature range of 300-400°C refers to the decomposition of Manganese carbonate to  $MnO_2$ . This oxide dissociates to  $Mn_2O_3$  (weight loss  $\approx 9\%$ ) at a temperature range of about 450-500°C. The decomposition of  $MnCO_3$  can be represented as follows:



The ammonium dichromate decomposes thermally in several steps, Fig. 2, with a total weighing loss of  $\approx 65\%$ . The decomposition steps observed here agree with those reported by EZ-Eldin(10).



To identify the phases formed during the thermal treatment, the X-ray diffraction spectra for pure  $\text{MnCO}_3$  heated at different temperatures  $250^\circ$ ,  $500^\circ$ ,  $750^\circ$  and  $1000^\circ\text{C}$  were recorded and summarized in Fig. (3,4 and 5).

For sample heated at  $250^\circ\text{C}$ , crystalline phase of  $\text{MnCO}_3$  (d-values 1.76, 2.17, 2.84 and  $3.66 \text{ \AA}^\circ$ )(11) was only detected. While the heated samples at temperatures of  $500^\circ$ ,  $750^\circ$  and  $1000^\circ\text{C}$  showed crystalline tetragonal phase for  $\text{Mn}_2\text{O}_3$  (d-values 2.49, 2.76, 3.08 and  $4.22 \text{ \AA}^\circ$ )(12). The crystallinity of this phase increase with temperature. At temperature of  $1000^\circ\text{C}$  crystalline phase of  $\text{Mn}_3\text{O}_4$  (d-values 1.49, 2.10, 2.54 and  $4.86 \text{ \AA}^\circ$ )(13) could be detected beside the phase of  $\text{Mn}_2\text{O}_3$ .

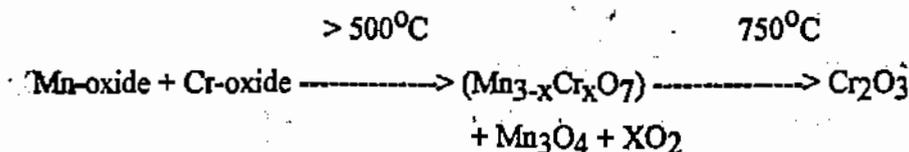
The X-ray diffraction pattern of heated ammonium dichromate sample at 500°C, Fig. 3, support the above thermal decomposition results which showed the formation of Cr<sub>2</sub>O<sub>3</sub> at 500°C(14).

The degree of crystallinity of Cr<sub>2</sub>O<sub>3</sub> increases with increasing the heating temperature, Figs. 4 and 5.

The X-ray diffraction patterns for the mixture samples (I, II, III) heated at 250°C showed the absence of any crystalline phases. The disappearance of the patterns of crystalline phases of MnCO<sub>3</sub>, which was observed in case of pure sample can be attributed to the interaction occurring between MnCO<sub>3</sub> and the composition products of ammonium dichromate.

For all mixtures heated at 500°C, the X-ray diffraction patterns showed crystalline phases of Mn<sub>2</sub>O<sub>3</sub>(12) and Cr<sub>2</sub>O<sub>3</sub>(14).

At temperature 750°C, crystalline phases of Cr<sub>2</sub>O<sub>3</sub> and Mn<sub>3</sub>O<sub>4</sub> could be detected. The formation of Mn<sub>3</sub>O<sub>4</sub> at 750°C could be explained as a result of certain reaction to form Mn<sub>3-x</sub>Cr<sub>x</sub>O<sub>7</sub>, which is then dissociate to Cr<sub>2</sub>O<sub>3</sub> and Mn<sub>3</sub>O<sub>4</sub>, (at 500°<T<750°C).



The mixed oxides of  $Mn_{3-x}Cr_xO_4$  was also detected as a result of the reaction between manganese carbonate and chromium nitrate at about  $500^{\circ}C$ (15).

The x-ray diffraction patterns for the mixtures heated at  $1000^{\circ}C$  showed an increase in the intensity of patterns for crystalline phases of  $Mn_3O_4$  and  $Cr_2O_3$ .

Figs. 6,7,8 and 9 illustrate the IR spectra for pure and mixed manganese and chromium salts heated at different temperatures. Fig. 6 shows the IR spectra of the pure salts and their mixtures heated at  $250^{\circ}C$ . The bands appeared at wave lengths of  $\approx 1810, 1437, 1087, 870$  and  $728\text{ cm}^{-1}$  indicate the presence of carbonate group. The increase in the concentration of chromium in the mixtures led to decrease intensity of the manganese carbonate bands and at the same time an increase in the intensity of the corresponding bands of chromium oxide at  $1100, 710, 650, 570, 555, 440$  and  $407\text{ cm}^{-1}$ . The IR-spectra for pure Mn-carbonate heated at  $500^{\circ}C$  showed the disappearance of carbonate bands of pure Mn-carbonate and the appearance of new bands at  $1150, 980, 845, 690, 610, 485$  and  $410\text{ cm}^{-1}$  which are characterized for  $Mn_2O_3$ .

For mixture samples heated at  $500^{\circ}C$ , the IR spectrogram showed a broad band pointing to the presence of some sort of chromates, which formed as a result of solid state reactions between manganese carbonate and ammonium dichromate. The IR spectra of calcined mixtures at  $750^{\circ}C$  showed

bands corresponding to  $\text{Cr}_2\text{O}_3$  and  $\text{Mn}_3\text{O}_4$ . Further increase in temperature,  $1000^\circ\text{C}$  increases the intensity of  $\text{Cr}_2\text{O}_3$  and  $\text{Mn}_3\text{O}_4$  bands, which confirmed the results obtained from X-ray.

## **Figure Captions**

Fig. 1: DTA and TG of manganese carbonate.

Fig. 2: DTA and TG of ammonium dichromate.

Fig. 3: X-ray diffraction patterns of ammonium dichromate, manganese carbonate and their mixtures calcined at 500°C.

1- Cr<sub>2</sub>O<sub>3</sub>                      2- Mn<sub>2</sub>O<sub>3</sub>

Fig. 4: X-ray diffraction patterns of ammonium dichromate, manganese carbonate and their mixtures calcined at 750°C.

1- Cr<sub>2</sub>O<sub>3</sub>                      2- Mn<sub>2</sub>O<sub>3</sub>                      3- Mn<sub>3</sub>O<sub>4</sub>

Fig. 5: X-ray diffraction patterns of ammonium dichromate, manganese carbonate and their mixtures calcined at 1000°C.

1- Cr<sub>2</sub>O<sub>3</sub>                      2- Mn<sub>2</sub>O<sub>3</sub>                      3- Mn<sub>3</sub>O<sub>4</sub>

Fig. 6: IR-spectra of ammonium dichromate, manganese carbonate and their mixtures calcined at 250°C.

Fig. 7: IR-spectra of ammonium dichromate, manganese carbonate and their mixtures calcined at 500°C.

Fig. 8: IR-spectra of ammonium dichromate, manganese carbonate and their mixtures calcined at 750°C.

Fig. 9: IR-spectra of ammonium dichromate, manganese carbonate and their mixtures calcined at 1000°C.

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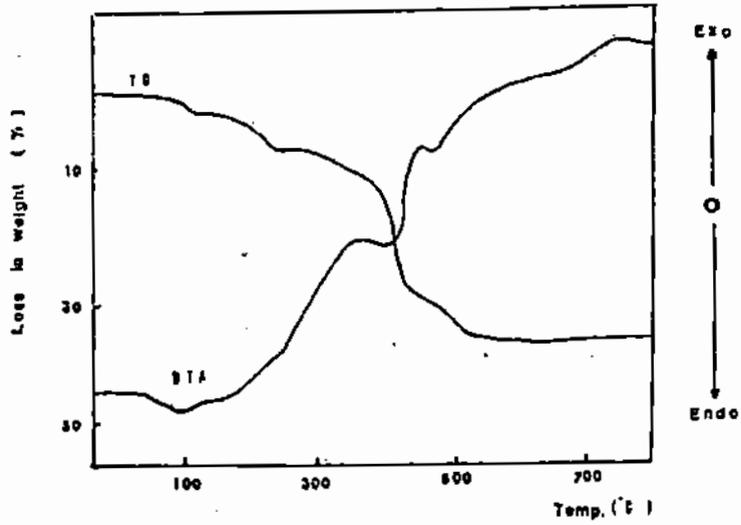


Fig 1

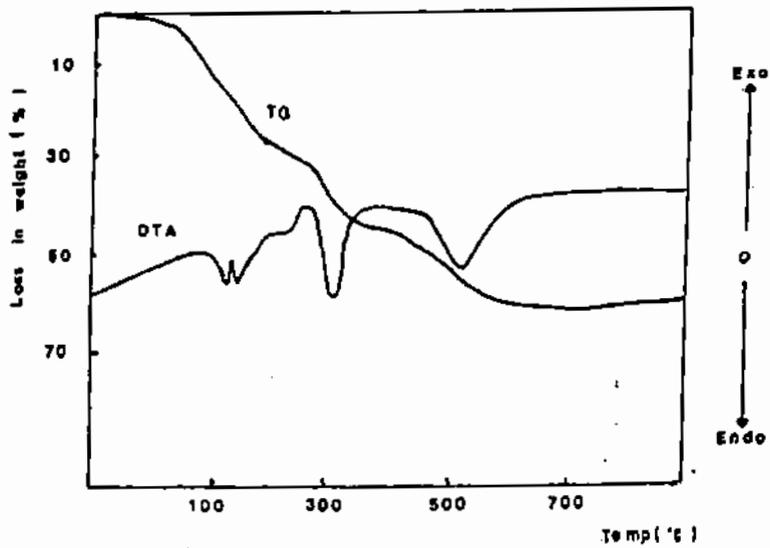


Fig 2

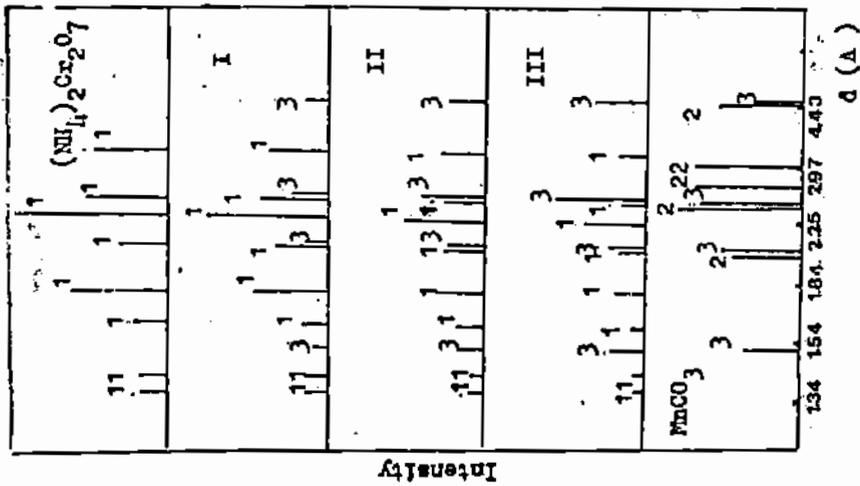


FIG 5

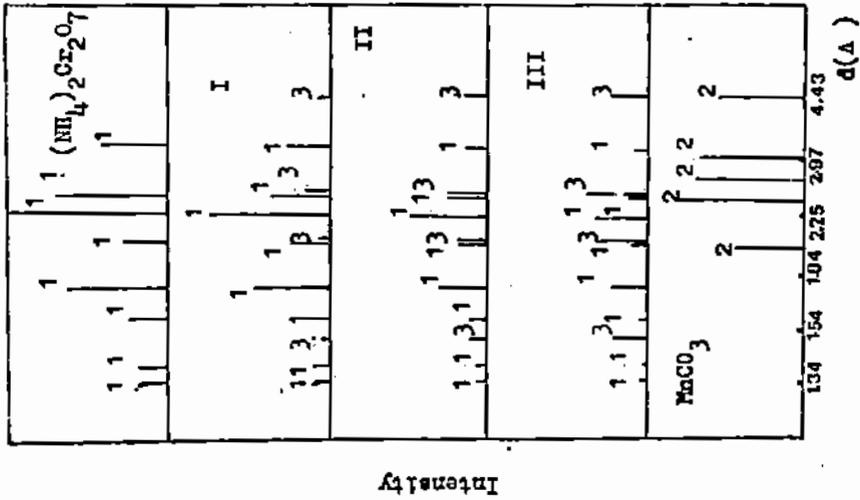


FIG 4

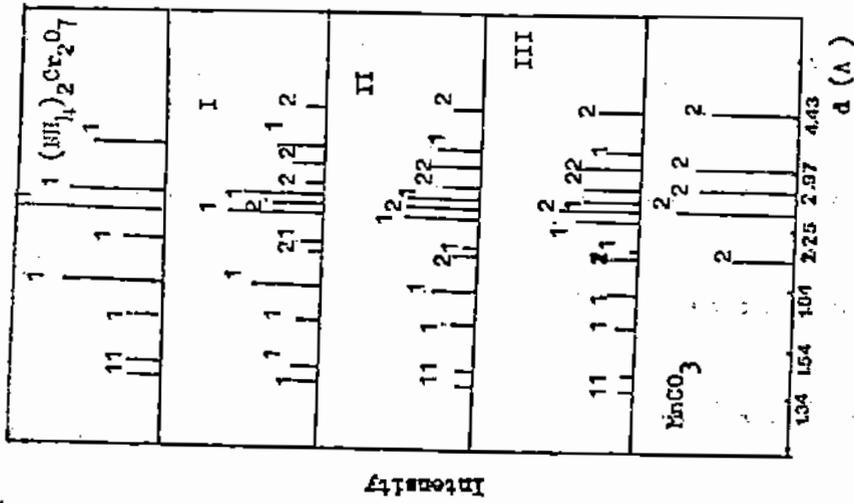


FIG 3

