
CHAPTER - III

: SOLID STATE BATTERY FORMATION :

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3.1 Introduction:

This chapter deals with the formation of solid state battery from our samples, sodium vanadate and potassium vanadate. This solid state battery formation was reported by Yashihico Ishibashi and Yutaka Takagi (1969) during the experimental study of electric field effect on the ferroelectricity of the KNO_3 crystals. They found that the electromotive force (e.m.f.) of about one volt is observed between two electrodes stucked into the fused crystal after a d.c. electric field of about 1 KV/Cm. once applied to the crystal at high temperatures and then taken off. The magnitude of this electromotive force, whose polarity is always the same as that of the applied d.c. voltage, is temperature dependent. It disappears at low temperatures, but recovers when the samples are heated again. There is a drastic change in e.m.f. at Curie temperature.

The e.m.f. decays with time, but decay constant is quite long; while the time constant of a condenser composed of KNO_3 and electrodes was estimated as less than 10^{-3} sec. Even after the electrodes are short-circuited the e.m.f. gradually recovers almost to the same voltage as expected without any short circuitry.

Usually at room temperature no large e.m.f. is observed. If we put a drop of water on the sample, however, soon some e.m.f. is seen to appear. From these facts, especially from a long decay constant and a recovery of e.m.f. after the short-circuiting, they concluded that some chemical reaction is taking place and a solid state battery is formed.

3.2 Experimental:

The experimental set up for formation of solid state battery is as shown in the Fig. 3.1. This experimental set-up consists of d.c. power supply, heating furnace, digital millivoltmeter, temperature-controller arrangement and multimeter. The heating furnace was specially made in our work-shop from non-conducting bricks in order to prevent loss of heat by radiation and conduction.

3.3 Solid State Battery of NaVO_3 :

In order to form the solid state battery, the pellet of NaVO_3 was placed between two platinum electrodes of crystal holder which was kept in the furnace. A d.c. electric field of about 1 KV/Cm was once applied to the pellet at high temperature 390°C . The dimension of the pellet used was 1 mm. Due to the d.c. applied electric field at high temperature the pellet was fused and electromotive force (e.m.f.) was observed between two electrodes stucked into the fused pellet. Then magnitude of electromotive force, whose polarity

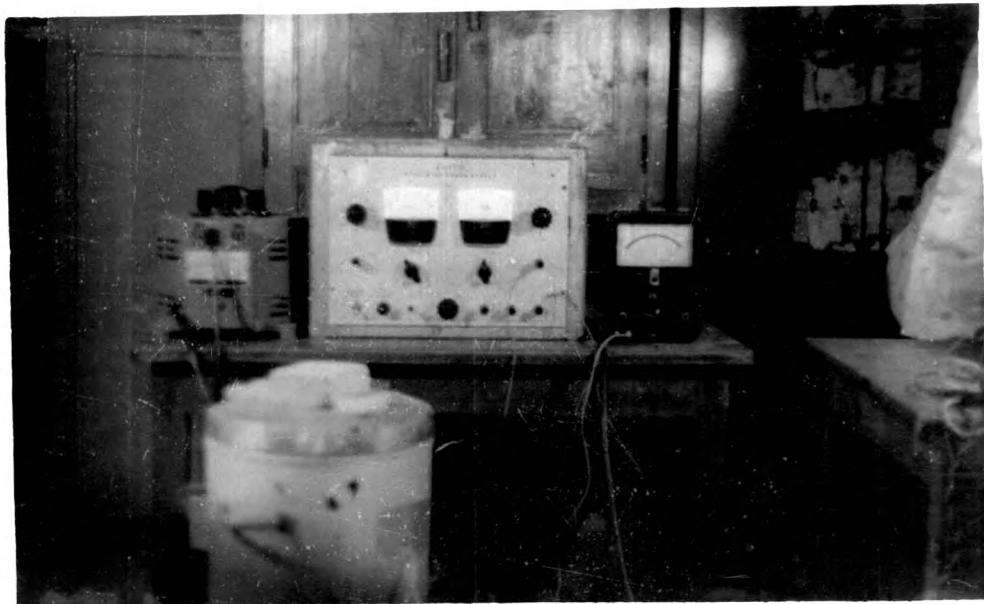


Fig: 3.1

is always the same as that of the applied d. c. voltage was measured with decrease and increase in temperature. The temperature dependence of electromotive force observed for a NaVO_3 fused sample is as shown in Fig. 3.2.

When the drop of water was put on cooled fused sample, some electromotive force was seen to appear.

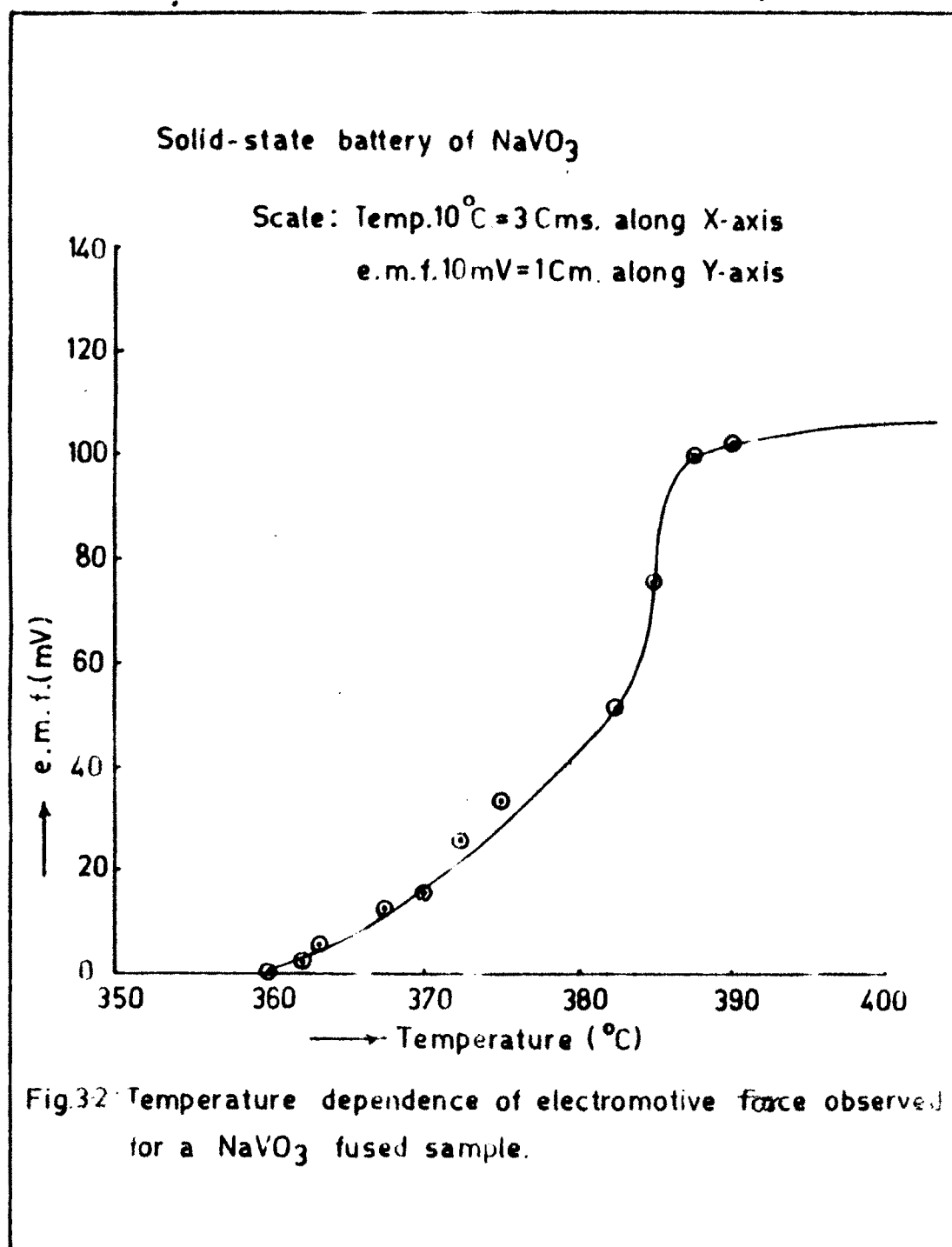
3.4 Solid State Battery of KVO_3 :

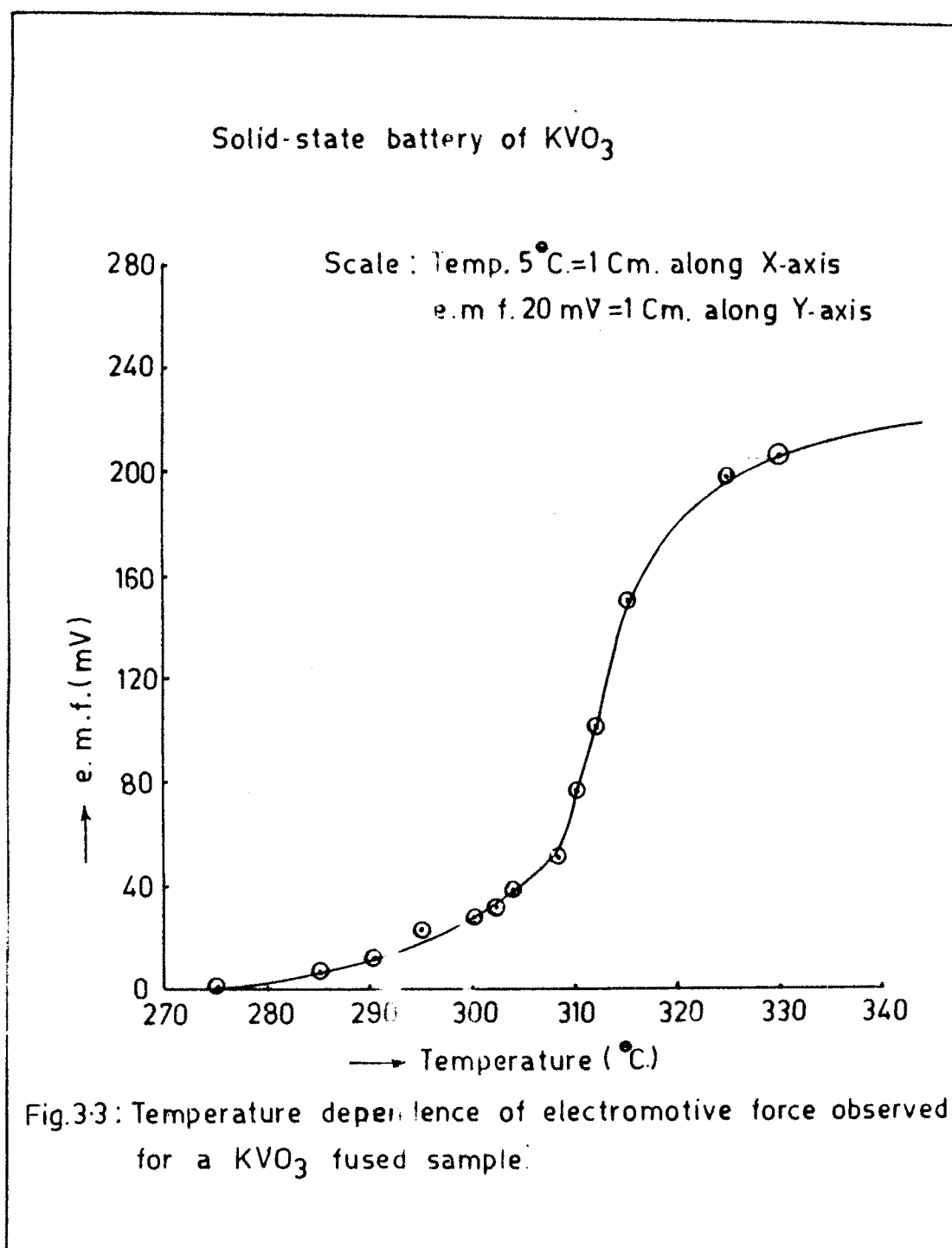
In order to get the solid state battery of KVO_3 , the pellet was introduced in the crystal-holder between two platinum electrodes and crystal holder was placed in the heating furnace. The dimension of the pellet used was 1.5 mm and d. c. electric field of about 1 KV/Cm. was once applied to the pellet at high temperature 330°C . Therefore, the pellet was fused and electromotive force (e.m.f.) was observed between two electrodes stucked into the fused pellet. Then magnitude of the electromotive force was noted down with decrease and increase in temperature. The Fig. (3.3) indicates the temperature dependence of electromotive force observed for a KVO_3 fused sample.

After putting a drop of water on cooled fused sample, some electromotive force was seen to appear.

3.5 Results and Discussion:

It is seen from the Figs. (3.2) (3.3) of electromotive force versus temperature for the samples sodium vanadate and

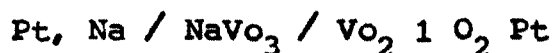




potassium vanadate that electromotive force is temperature dependent. At the Curie temperature, there is a drastic change in the electromotive force. Therefore the drastic changes in e.m.f. are observed at 380°C for NaVO_3 and 312°C for KVO_3 in the Figures, (3.2) and (3.3) respectively. The e.m.f. disappears at low temperatures but recovers when the samples are heated again.

One of the possible explanations for getting electromotive force in the formation of solid-state battery is as follows:

By the application of d.c. electric field to the sample NaVO_3 , a part of it is guessed to be decomposed into Na , VO_2 and O_2 ions. The VO_2 and O_2 get out of positive terminal as gas and Na stays near negative electrode. So we obtain the battery of:



On the similar line the recovery of e.m.f. by a drop of water can be explained as that sodium existing near the negative terminal react with water and NaOH and H_2 are formed. Thus we get H_2 gas at negative terminal and O_2 gas at positive terminal.

In the similar manner by the application of d.c. electric field to the sample KVO_3 , a part of it is guessed

to be decomposed into K, Vo_2 and O_2 ions. The Vo_2 and O_2 get out of positive terminal as gas and K stays near negative electrode. Therefore we obtain the battery of:



On the similar line the recovery of e.m.f. by a drop of water can be explained as that potassium existing near the negative terminal react with water and KOH and H_2 are formed. Thus we get H_2 gas at negative terminal and O_2 gas at positive terminal.

Since NaVO_3 or KVO_3 battery is formed by the application of a d.c. electric field as mentioned above, it will be quite difficult, sometimes even impossible, to study d.c. field effects on ferroelectricity of NaVO_3 or KVO_3 such as the shift of ferroelectric phase transition temperature and as the change of dielectric constant due to d.c. electric field.

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