

THE ACTIVITY OF γ - Al_2O_3 AND La_2O_3 IN PEROXIDE DECOMPOSITION

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ABSTRACT

The catalytic activities of γ - Al_2O_3 and La_2O_3 in the chemical composition of hydrogen peroxide has been studied via the gasometric assembly for oxygen evolution. The La_2O_3 was found to catalyze the decomposition reaction while γ - Al_2O_3 and α - Al_2O_3 was not effective as catalysts for the peroxide decomposition. The difference in the catalytic behaviors of La_2O_3 and Al_2O_3 (α and γ -phases) have been explained in terms of differences in the electronic structures of La^{3+} and Al^{3+} .

Key words: Production, chemical composition, hydrogen peroxide, catalytic activities.

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INTRODUCTION

The production of oxygen gas has for many years depended on the electrolysis of water. However, a lot of problems are often encountered in the area of storage of the electrolysis products. To circumvent this problem, oxygen is often produced by the catalytic decomposition of hydrogen peroxide. The choice of a suitable catalyst for hydrogen peroxide has been very difficult.

Onuchukwu and Zuru as cited in Ita (1998) have reported the possibility of producing oxygen gas by the catalytic decomposition of hydrogen peroxide involving the use of cobalt-ferrites. A catalyst is necessary in the chemical decomposition of hydrogen peroxide, since it has been found that the rate of self-decomposition of hydrogen peroxide according to the reaction;



The temperature of the reaction was 298K per $1.3 \times 10^{-4} \text{cm}^3 \text{S}^{-1}$ which is considered to be very slow. The use of $\gamma\text{-Al}_2\text{O}_3$ and La_2O_3 as catalysts in the decomposition of hydrogen peroxide has not yet been reported (to the best of our knowledge). In this work, we report the activity of $\gamma\text{-Al}_2\text{O}_3$ and La_2O_3 in the chemical decomposition of hydrogen peroxide. The use of $\gamma\text{-Al}_2\text{O}_3$ as a binder in commercial SnO_2 sensor has been reported by Yamazoe as cited in Ita and Offiong (1997). $\gamma\text{-Al}_2\text{O}_3$ is also used as a catalyst in some systems (Ita, 2001). Ita (2001) has reported on the possibility of using La_2O_3 as a starting material in the synthesis of the acetylacetonate complex of lanthanum which has been used as a precursor in the synthesis of several important lanthanum -based perovskites and spinels for technological applications. An attempt has also been made to explain the differences in the catalytic activities of the oxides studied in terms of differences in their electronic structures.

EXPERIMENTAL PROCEDURE

The $\gamma\text{-Al}_2\text{O}_3$ used for this work was synthesized and characterized from aluminum acetylacetonate using a novel sol-gel route as described by Onuchukwu (1990) while the La_2O_3 was supplied by Prof. C.N. R. Rao, JNCASR, Bangalore, India. However, the La_2O_3 was heat-treated at 100°C for 24hrs before use.

The catalytic activity of the oxides for hydrogen peroxide decomposition was evaluated by monitoring the volume of oxygen evolved with time in

a gasometrical assembly. The detailed construction of the gasometrical assembly has been reported elsewhere (Yamazoe, 1991). A constant catalyst weight (0.097g) was injected into a thermostated reaction vessel containing 100cm^3 of 1.75mol dm^{-3} H_2O_2 in 5mol dm^{-3} KOH as diluent for each oxide specimen and the volume of O_2 evolved was recorded from the depression in the paraffin oil level. The time-dependent volume of evolved oxygen was monitored at 30s intervals in all the cases studied. The maximum recorded V_{max} , was also indicative that the reaction was complete (Ita, 1998). The experiment was performed at ambient temperature ($28 \pm 1^\circ\text{C}$).

RESULTS AND DISCUSSION

The juxtaposed plot of volume of oxygen evolved with time in a gasometric assembly containing La_2O_3 as a catalyst in $\text{H}_2\text{O}_2/\text{KOH}$ system is presented in figure 1. During the experiment, it was observed that when hydrogen peroxide was allowed to undergo self-decomposition reaction, there was no noticeable nor detectable volume of oxygen recorded even though Onuchukwu and Zuru (1986) had state earlier that for self-decomposition of the hydrogen peroxide, the oxygen evolution rate at 298K is $1.3 \times 10^{-4} \text{cm}^3\text{S}^{-1}$. Therefore, the plot 1 was corrected to take into account this observation. In the presence of La_2O_3 , reasonable volume of oxygen evolved, reaching a maximum value, V_{max} of 1.6cm^3 at 180s. This observation indicates that La_2O_3 is an effective catalyst in the peroxide decomposition. Detailed activity-structure relationship,

particularly the kinetics of the catalytic process at higher temperatures up to 333K is being further investigated in our laboratory. However, we have been able to establish the fact that La_2O_3 is effective as a catalyst in the chemical decomposition of hydrogen peroxide at room temperature ($\pm 28^\circ\text{C}$).

On the contrary, $\gamma\text{-Al}_2\text{O}_3$ is found to be ineffective in the $\text{H}_2\text{O}_2 / \text{KOH}$ system. It is therefore not a catalyst in the chemical decomposition of hydrogen peroxide as no detectable volume of oxygen evolved throughout the 180s of duration of the experiment. A catalyst is assumed to be specific in its action. While $\gamma\text{-Al}_2\text{O}_3$ is effective in some systems (Ita, 2001), it is ineffective in the $\text{H}_2\text{O}_2/\text{KOH}$ system and cannot catalyze the reaction below:



The $\gamma\text{-Al}_2\text{O}_3$ was heated to 900°C for 24hrs to obtain the $\gamma\text{-Al}_2\text{O}_3$ phase (Onuchukwu, 1995) which was also found to be ineffective as a catalyst in the $\text{H}_2\text{O}_2/\text{KOH}$ system.

CONCLUSION

One important question that arises is why La_2O_3 was found to catalyze the reaction (1) and Al_2O_3 (in γ and α) phases did not catalyze the

reaction (1) above. We shall attempt to answer the question by looking at the electronic configuration of Al^{3+} and La^{3+} since these make the difference in La_2O_3 and Al_2O_3 . The electronic configuration of Al^{3+} is well-known to be $1s^2 2s^2 2p^6 3s^0 3p^0$ while that of La^{3+} is represented as $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6 5d^0 5f^0 6s^0$. A cursory look at the two electronic configuration reveals that Al^{3+} has no electron in the d-orbital while La^{3+} , uses its incomplete $5d^1$ orbital in bonding. We believe that d-orbital involvement has great influence in the catalysis. Thus the catalytic activity may be determined by the structure of the d-orbital and the disappearance of catalytic properties with the disappearance of fraction electron deficiencies in the d-orbital strongly suggest that these deficiencies play a critical part in peroxide decomposition catalysis.

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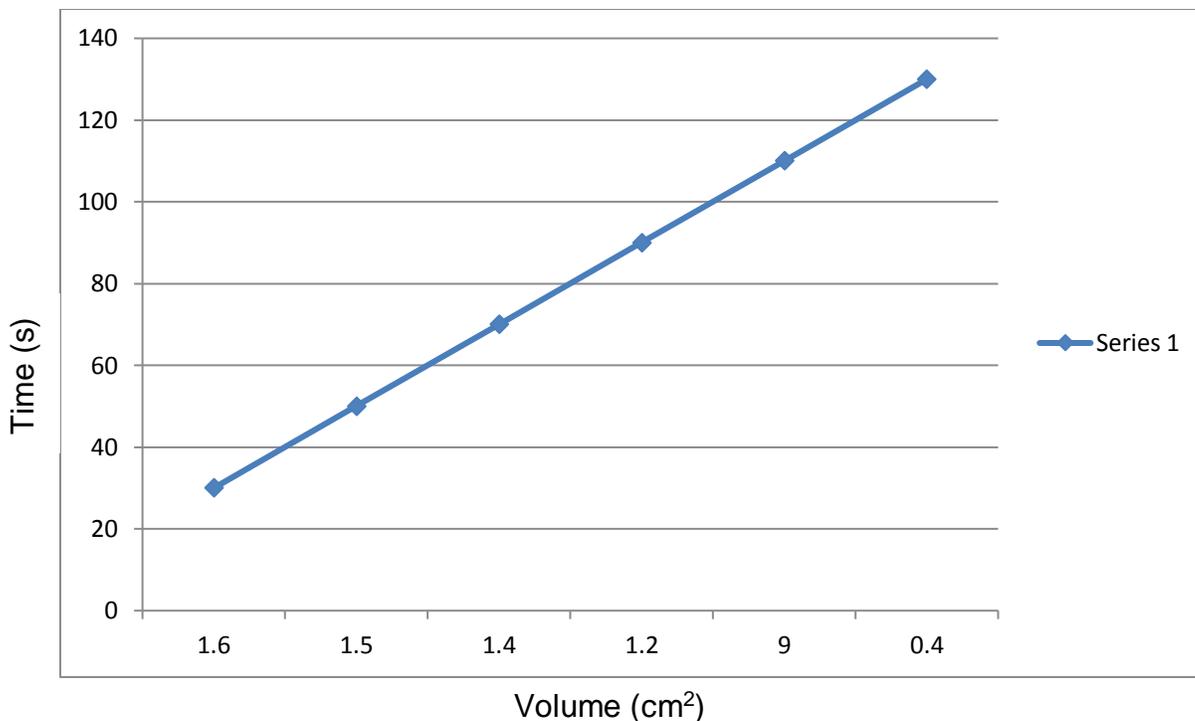


Fig.1. Variation of volume of oxygen with time for La₂O₃ catalyst in H₂O₂/KOH system

REFERENCES

- Ita, B. I. (1998). Synthesis and characterization of some semi-conducting oxides perovskites and spinel's. Ph.D Thesis submitted to University of Calabar, Nigeria.
- Ita. B. I. and Offiong, O. E. (1997). The inhibition of mild steel corrosion in hydrochloric acid by 2, 2¹- pyridil and α-pyridoin. *Mater.Chem. Phys*, (51): 203-210.
- Ita. B. I. (2001). Synthesis and X-ray Diffraction Studies of γ- Al₂O₃ using aluminum acetylacetonate (AAA) precursor via a novel sol-gel route. *Glob. J. Pure and Appl. Sciences*, 7 (1): 81-84.
- Martin, S. E. and weaver, M. L. (1992). High-purity alumina. *Am. Ceram. Soc. Bull.* (72):71-77.
- Onuchuckwu, A. I. and Zurn, A. B. (1986). The cobalt-ferite, Co_xFe_{3-x}O₄, activity in the catalytic chemical decomposition of hydrogen peroxide. *Mater. Chem. phys.* 15 (1): 131-138.
- Onuchukwu, A. I. (1990). The inhibition of aluminum corrosion in alkaline medium 11: influence of hard bases. *Mater. Chem. Phys.*, 24 (12):337 -342.
- Yamazoe, N. (1991). New approaches for improving semiconductor gas sensors. *Sensors and Actuators B.* 5 (1): 7-19.