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CALCINATION OF METAL COMPOUND USING MICROWAVE FURNACE

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ABSTRACT

Calcination is a process of heating a substance under controlled temperature and pressure it could in the presence or absence of oxygen. Among many applications of calcination, one of the applications is the conversion of a radioactive metal compound to its oxide. This process can be done using an electric furnace, but because of many disadvantages of furnace-like low heating efficiency and heat loss, the microwave is used as an alternative heating medium to perform calcination. The principle of microwave and dielectric loss factor is the major concern highlighted in this paper... The main concern here for calcination is the conversion of the metal compound to its oxide using oxide as a feed material. Various combinations were tested while performing the experiments. The data represented in this paper are similar to the original data

Key Words - Calcination of metal compound, Microwave, Dielectric loss factor,

INTRODUCTION

IUPAC defines calcination as heating to high temperature in air or oxygen however, calcination can also be explained as thermal treatment process in absence or limited supply of oxygen applied to ore or other solid substance to bring out other thermal decomposition. A calciner is a cylinder or a circular structure, that rotates inside a heated furnace and performs indirect heating. This process is carried out under controlled temperature and atmospheric pressure.

In order to convert metal compound to its oxide, calcination is done at temperature ranging from 500-600^oC. There are different studies and experiment performed for calcination of metal compound. This paper focuses on calcination of radioactive metal compound to its oxide at temperature up-to 600^oC. Here feed material is added to the metal compound; this feed material can be oxide of radioactive element for example triuraniumoctaoxide.

Using feed material in the process is very effective and less time consuming as compared to other conventional calcination process like resistive furnace. In this resistive furnace, there is immense heat loss through the body; therefore, the heating efficiency of the system is reduced to 70%. This paper focuses on use of alternative heating technique for calcination of metal compound to form its oxide.

MICROWAVE CALCINATION OF METAL COMPOUND

The thermal decomposition of metal compound occurs at several stages, since the material is radioactive metal compound of ammonia, during the process of calcination, ammonia is released which is detected by bubbles in bucket filled with water. The oxide is formed by self-reduction of ammonia within the solid at 650^oC.

When we use microwave as a furnace for calcination purpose, we add feed material which is basically the oxide of the radioactive metal. By adding, it increases the speed of reaction and also it will reduce the time of initiation and conversion. In electromagnetics, loss implies, conversion of electrical energy into heat. The factor is termed as dielectric loss factor, which plays an important role in microwave calcination.

Dielectric Loss Factor

The dielectric loss factor ε'' is related to complex permittivity, it is a measure of loss of energy in dielectric material through conduction, slow polarization currents. Dielectric loss also quantifies, a dielectric material's inherent dissipation of electromagnetic energy. It is termed by tangent of δ.

These properties provide an indication of the electrical insulating ability of the material. Dielectric loss factor of oxide is more as compared to metal compound therefore, they generally absorb a large fraction of the energy when placed in a microwave field resulting in instantaneous heating. The dielectric loss factor for the material, ε ", which expresses the degree to which an externally applied electric field will be converted to heat, is given by $\varepsilon'' = \varepsilon' \tan \delta$ The loss tangent, tan δ, provides an indication of how well the material can be penetrated by an electrical field and how it dissipates electrical energy as heat.

EXPARIMENTAL APPROACH AND RESULTS

Experiments are performed by lumping and mixing the feed material in the microwave. Our main focus here is to convert the metal compound to its oxide, and microwave calcination is employed in this work, hence timing of initiation and conversion is important. When we use resistive furnace for calcination purpose, the time consumed is more and secondly, the heating efficiency is also deteriorating. Therefore, by experimenting various combinations of metal compound and feed material we can determine which combination gives us optimum data which is needed.

RESULTS AND DATA CHART

Table 1, 2, & 3 shows, time required for initiation of conversion of metal compound. Here we are keeping metal compound content i.e. 30 grams and changing oxide in percentage manner from 10-100%. Table 1 & 3 shows the starting time required for respective change in % oxide. When oxide is placed as lump with metal compound. We can see that there is increase in starting time as we decrease the percentage oxide. The statistical data (chart 1) shows the similar characteristic, when the value of oxide is 10%, the time taken for triggering is 15 mins whereas when the percentage value of OXIDE is set to 20% the triggering time is reduced further. After 50% the time remains constant.

A. Data when quantity of metal compound is kept constant and oxide is varied in percentage manner. Table 1 shows the result when both of these material are mixed uniformly for microwave calcination. From this table we can see that with the increase in percentage oxide, the starting time is reduced, where as in table 2 shows the data when oxide is lumped with the metal compound the reading in table 2 shows that when lumped, the time for initiation of conversion remains constant for all value of change in percentage oxide. Chart 1 and 2 shows characteristic of table 1 and 2 respectively.

Table 1: Time of initiation of conversion when oxide is mixed uniformly with metal compound

Metal Compound	%Oxide (feed material)	Starting Time
30	10	20
30	15	9.6
30	20	6.7
30	50	2.5
30	75	2.4
30	100	2

Table 2: Time of initiation of conversion when oxide is lumped with metal compound

Metal Compound	%Oxide	Starting Time
30	10	4.0
30	15	4.25
30	20	4.03
30	25	3.59
30	50	4.0

Characteristics:

Chart 1: When oxide is mixed with metal compound

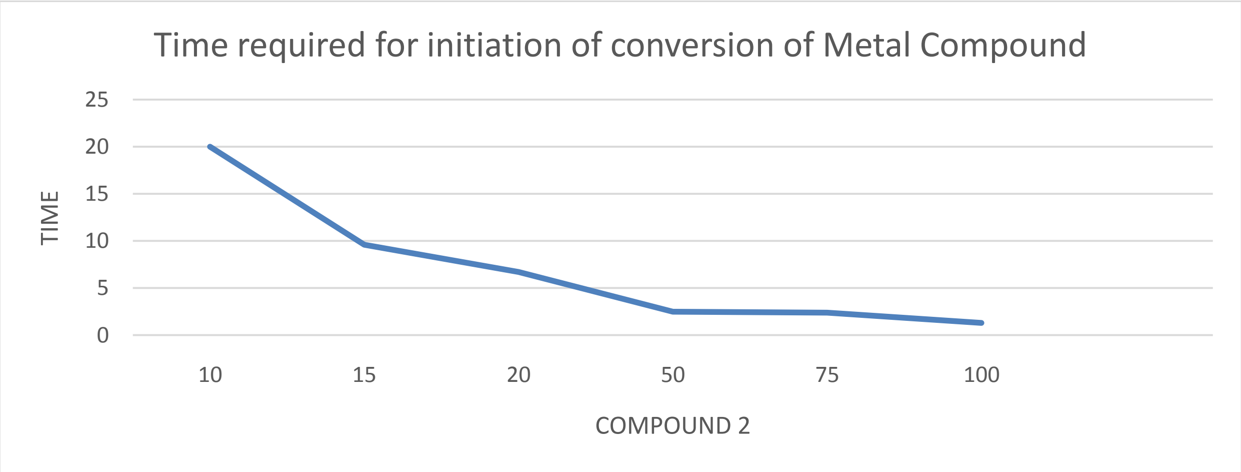
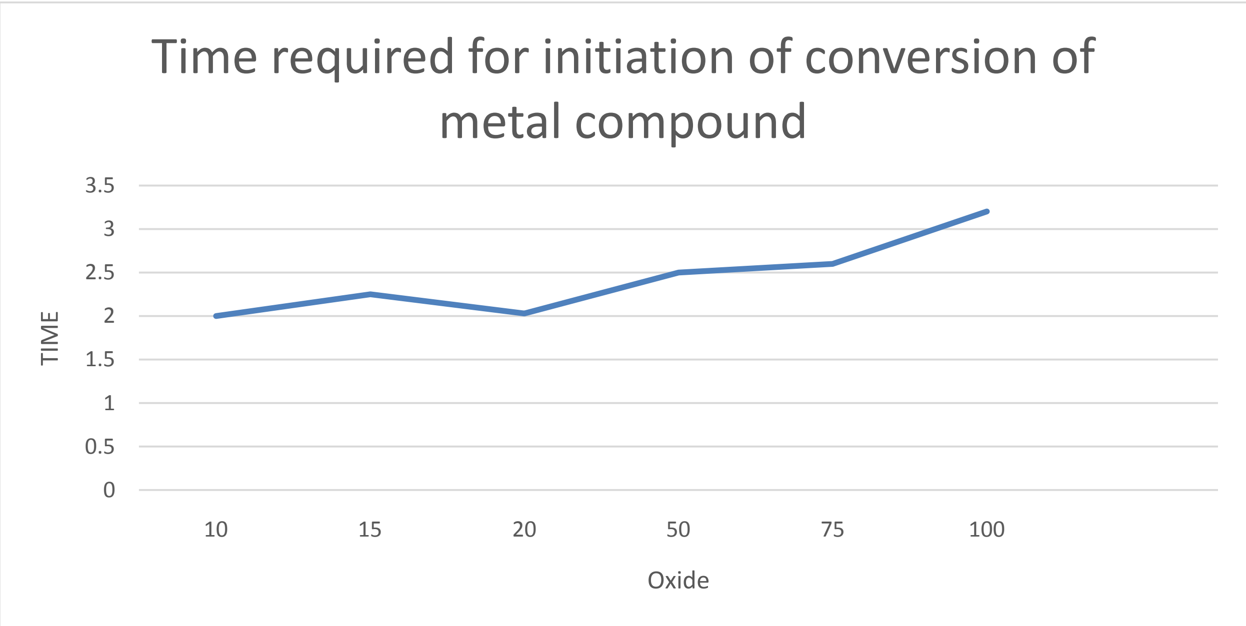


Chart 2: When oxide is lumped with meta compound



In this, we are varying the quantity of metal compound and keeping oxide value constant. Here, in this experiment we are more focusing on the completion time. i.e. the time at which metal compound is converted into its oxide. Table 3 shows the data when oxide is mixed uniformly with the metal compound whereas table shows data of lump. From these two table and their respective characteristics we can see that the completion time is constant for all value of change in metal compound.

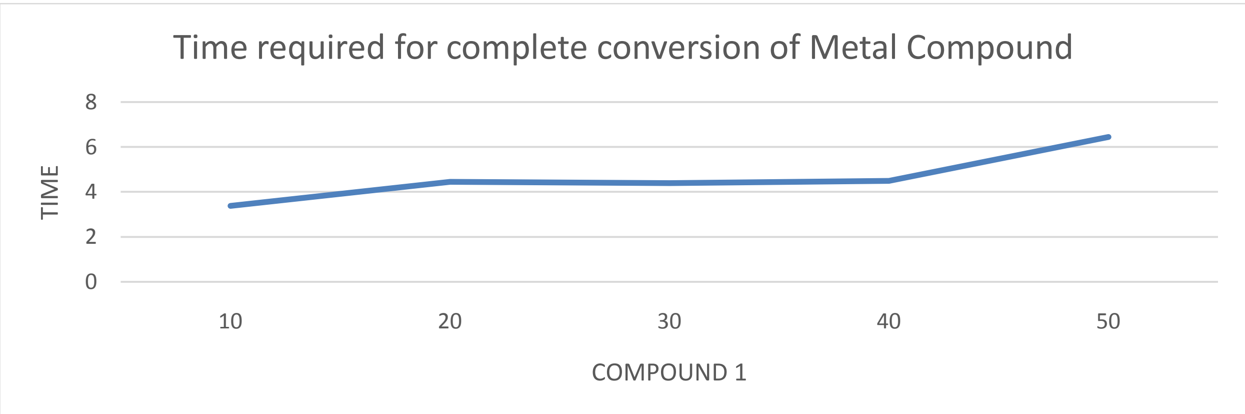
Metal Compound	%Oxide	Starting Time	Completion Time
15	10	1.44	3.38
15	20	2.13	4.45
15	30	2.00	4.40
15	40	3	5.5
15	50	4.20	6.45

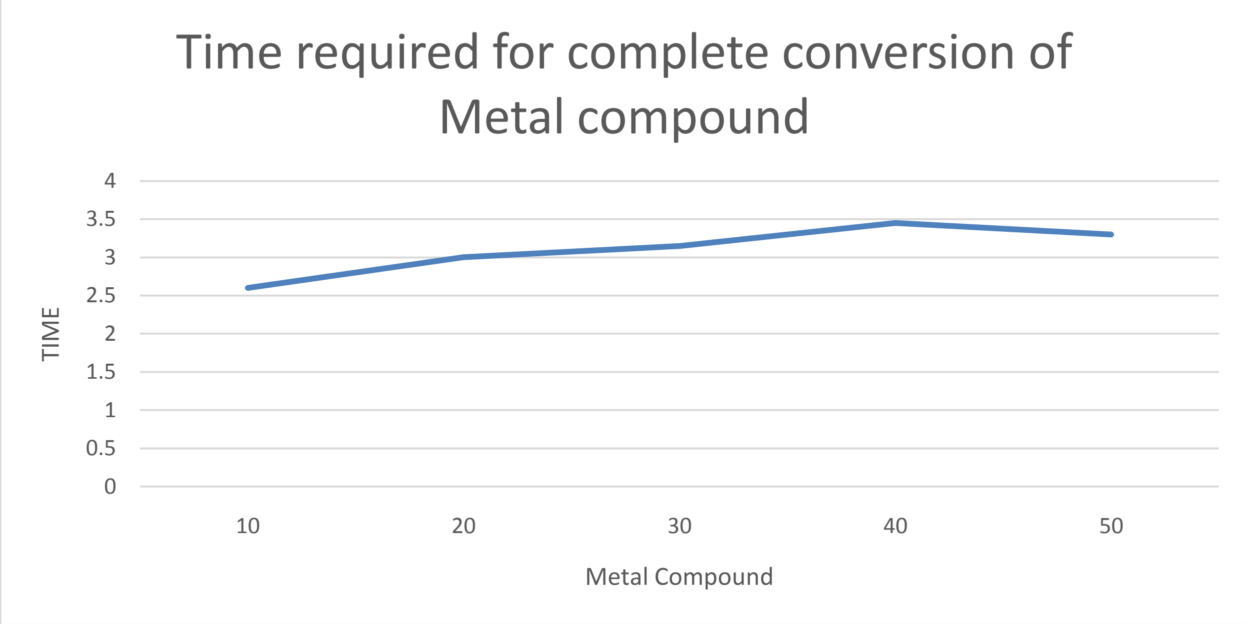
Table 3: Completion time of mixed mixture

COMPOUND 2	COMPOUND 1	Starting Time	Completion Time
15	10	0.40	2.6
15	20	2.08	3.0
15	30	1.00	3.15
15	40	1.05	3.45
15	50	1.15	3.30

Table 4 : Completion time of lumped mixture

CHARACTERISTICS





1.1. Why Lumping the oxide gives better result?

From the above data we can say that lump characteristic are more time reliable than mix. This is because, when we lump metal oxide, the surface area of initiation of heating is confined to the same place and secondly, the dielectric loss factor of the oxide is more as compared to metal oxide hence the heat transfer and absorption takes place at faster rate. On other hand if we mix the oxide, the per molecule of oxide will take longer time to absorb heat and hence heat transfer takes longer time. We can see that the higher the amount of oxide in the mixture the lesser the time, and this is not the case we want our main target to perform the calcination of metal compound therefore the lumping the mixture with the metal compound shows promising results.

CONCLUSION

In the process of calcination, we are adding feed material to the metal compound. This feed material as we discussed above, is an oxide of metal compound which is radioactive; has certain properties which helps in the reaction. First is the dielectric loss factor of the oxide is more as compared to metal compound hence the heat absorption is more which leads to faster and efficient heating and increases the rate of calcination. Second is the chemical property, the oxide posses a property that, it remains unaffected till the temperature of 800^{o}C and converts all its metal compound to itself, hence by adding it to the compound will act as a catalyst. From the data and characteristic we understood that when we lump the oxide with the metal compound, we are getting the optimum and desired result.

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