for two hours on Nuova-II stir plate. After this dilutions (300ml distilled H_2O) were made for filtration. It was carried out through precision suction pump.

Finally, the filtrate was removed and concentrated to the density between 1.48-1.51 g/cm^3 and it was crystallized in the crystallization dish at room temperature 27°C. Crystals were analysed for Zinc contents on Atomic Absorption Spectrophotometer.

Small, orthorhombic and shiny crystals were obtained. Physical and chemical tests were performed to ensure that the recovered chemical was Hepta Hydrated Zinc Sulphate ($ZnSO_4.7H_2O$).

Confirmatory Test for $ZnSO_4$

$$ZnSO_4 + 2NaOH \longrightarrow Zn(OH)_2 + Na_2SO_4$$

(solution) (solution) white ppts

The data thus collected for the characters like recovery (%), yield (g), weight of un-reacted cake (g), total Zn %age in un-reacted cake and water soluble zinc %ages in crystals were statistically analysed having Complete Randomized Design (CRD) for their variances following Steel and Torrie (1980).

Mean square values of the characters from analysis of variance

S.O.V.	D.F	Recovery (%)	Yield (g)	Weight of Un-reacted Cake (g)	Total Zn %age in Un-reacted Cake.	Water soluble Zn %age in crystals.
Treatments	04	80.871 **	117.749 **	152.985 **	34.959 **	0.100 **
Error	10	2.069	2.640	1.334	0.518	0.091

**Highly significant

RESULTS AND DISCUSSIONS

Analysis of variances indicated highly significant differences for all the characters due to different treatments of Zinc substrate on the recovery percentage of hepta hydrated Zinc sulphate (Table-1).

Recovery Percentage

Maximum recovery of $ZnSO_4.7H_2O$ (88.78%) was obtained by using Zinc dust : 60% H_2SO_4 followed by Zinc catalyst ZnO (88.06%) and Zinc ash : 50% H_2SO_4 (82.69%) (Table 2). The results of three treatments showed that any one of these can be applied to obtain maximum recovery of $ZnSO_4.7H_2O$. Whereas the treatment with Zinc dust : 80% H_2SO_4 and Zinc ash: 30% H_2SO_4 produced $ZnSO_4.7H_2O$ (78.96% and 77.30%) respectively.

Further observations revealed that the best concentration of H_2SO_4 to be used with Zinc dust was 50 or 60%. If the concentration of H_2SO_4 is increased (80%) or decreased (30%), the recovery percentage will also reduce significantly.

The use of any particular treatment will however depend upon the cost involved. Thus, the treatment, which is most cheaper among the highest three, should be used.

Yield of $ZnSO_4.7H_2O$

A similar trend was observed for this parameters. Increase or decrease of H_2SO_4 concentration from 50 and 60% also significantly reduced the yield of $ZnSO_4.7H_2O$.

A comparison of treatment means (Table-1) depicted that the maximum yield of $ZnSO_4.7H_2O$ (128.1g) was obtained by using Zinc ash:60% H_2SO_4 followed by Zinc catalyst ZnO (124.5g). Whereas treatments with Zinc dust:80% and 30% H_2SO_4 produced the minimum $ZnSO_4.7H_2O$ (115.2g and 113.2g respectively). The results suggested that either Zinc ash with 60% H_2SO_4 or Zinc catalyst can be used to obtain higher production of $ZnSO_4.7H_2O$. However, the cheaper treatment should be utilized.

Weight of Un-reacted Cake (g)

During the production of $ZnSO_4.7H_2O$ by using various treatments on Zinc dust, the un-reacted material settles down. The weight of that un-reacted material relates to the yield and recovery of the $ZnSO_4.7H_2O$. Greater the weight of un-reacted cake lesser will be the yield and recovery of $ZnSO_4.7H_2O$ and vice versa.

It became evident from Table-4 that by using the method of Zinc catalyst treatment for the production of $ZnSO_4.7H_2O$ was the most productive because it produced the lowest amount (19.17g) of un-reacted cake after the reaction followed by the method of using Zinc ash with 60% H_2SO_4 (22.70g). These two treatments were statistically at par. Rest of the treatments produced the higher amount of un-reacted cake and thus, are not suitable.

Total Zinc in Un-reacted Cake (%)

A higher percentage of Zinc in un-reacted cake indicates a lower recovery of Zinc in terms of $ZnSO_4.7H_2O$. Therefore, greater the Zinc percentage in the un-reacted cake lesser will be the Zinc recovery and vice versa. Treatment which gives lesser Zinc percentage in the un-reacted cake will thus be considered better.

Table 1. Effect of different H_2SO_4 concentrations and two raw materials (Zinc dust and Zinc Catalyst) on weight, yield, recovery and total Zinc content in unreacted cake

Treatment	Weight (g)	Yield	Recovery (%)	Total Zinc
Zinc Catalyst Zno	19.17 d	124.5 ab	88.06 a	19.94 a
Zinc dust + 30% H_2SO_4	34.82 ab	113.2 c	77.30 b	17.97 a
Zinc dust + 50% H_2SO_4	28.50 bc	121.9 abc	82.69 ab	13.02 bc
Zinc dust + 60% H_2SO_4	22.70 cd	128.1 a	88.78 a	11.80 c
Zinc dust + 80% H_2SO_4	35.15 a	115.2 bc	78.96 b	16.85 ab

Table-5 indicated that the lowest (11.80%) of Zinc in un-reacted cake was obtained with the use of 60% H_2SO_4 with Zinc dust followed by the treatment of 50% concentration of H_2SO_4 with Zinc ash (13.02%). Method of using Zinc catalyst with H_2SO_4 produced the maximum (19.94%) of zinc in the un-reacted cake.
Thus the treatment of Zinc dust with 60% H_2SO_4 was suggested to be useful.

Water Soluble Zinc Percentage in Crystals:

Water soluble Zinc percentage in the final product is a characteristic value which should be between 22 to 23 percent (Murphy & Walsh, 1972). Percentage in lesser or greater amount indicates that the end product is incomplete or other than the required product.
It was found that Zinc percentage in the crystals of the end product following all the treatments lies between 22 and 23 (Table-6) and the difference was non-significant indicating the adequacy of the treatments for the process.

CONCLUSION

On the basis of overall performance, it was found that digestion of 60% H_2SO_4 with Zinc dust produced the maximum $ZnSO_4.7H_2O$ recovery (88.78%) and yield (128.1g) with lesser weight of un-reacted cake (22.70g) and the lowest percentage of Zinc in the un-reacted cake (11.80%). Thus the most suitable method suggested for producing $ZnSO_4.7H_2O$ in higher amount would be the use of 60% H_2SO_4 with Zinc dust with increasing/decreasing the Zinc contents in the Zinc dust/Zinc catalyst also affect the yield or recovery percentage of the product.

Table 2. LSD Test for Recovery (%) of $ZnSO_4.7H_2O$

Treatments Order	*Recovery (%)*	*Ranking*
Zinc dust : 60% H_2SO_4	88.78	A
Zinc catalyst ZnO	88.06	A
Zinc dust : 50% H_2SO_4	82.69	AB
Zinc dust : 80% H_2SO_4	78.96	B
Zinc dust : 30% H_2SO_4	77.30	B

Table 3. LSD Test for Yield (g) of $ZnSO_4.7H_2O$

Treatments	*Yield (g)*	*Ranking Order*
Zinc dust : 60% H_2SO_4	128.1	A
Zinc catalyst ZnO	124.5	AB
Zinc dust : 50% H_2SO_4	121.9	ABC
Zinc dust : 80% H_2SO_4	115.2	BC
Zinc dust : 30% H_2SO_4	113.2	C

Table 4. Comparison of treatment means of un-reacted cake (g) for weight

Treatments Order	*Weight (g)*	*Ranking*
Zinc dust : 80% H_2SO_4	35.15	A
Zinc dust : 30% H_2SO_4	34.82	AB
Zinc dust : 50% H_2SO_4	28.50	BC
Zinc dust : 60% H_2SO_4	22.70	CD
Zinc catalyst ZnO	19.17	D

Table-5. Comparison of treatment means for total Zn % in un-reacted cake

Treatments	*Zinc (%)*	*Ranking Order*
Zinc catalyst ZnO	19.94	A
Zinc dust : 30% H_2SO_4	17.97	A
Zinc dust : 80% H_2SO_4	16.85	AB
Zinc dust : 50% H_2SO_4	13.02	BC
Zinc dust : 60% H_2SO_4	11.80	C

Table-6. Mean Values of water soluble Zn % in crystals after applying different treatments

LSD test was not applicable due to non-significant results.

Table of Means

6	7	5	Total
*	1	22.540	67.620
*	2	22.390	67.170
*	3	22.890	68.670
*	4	22.660	67.980
*	5	22.627	67.880

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