

APPENDIX A: Co-precipitation process

A.) Data available:

Chemical	Molecular Weight, g / mol
MgCl ₂ .6H ₂ O	203.31
CuCl ₂ .2H ₂ O	170.48
ZnCl ₂	136.29
FeCl ₃ .6H ₂ O	270.30
NaOH	40.00
Mg	24.31
Cu	63.55
Zn	65.38
Fe	55.85

B.) The calculation of the weight of chlorides:

Weight fraction of the principal element in the chlorides are:

1. For MgCl₂.6H₂O, weight fraction of Mg, $WF_{Mg} = \frac{24.31}{203.31} = 0.1196$

2. For CuCl₂.2H₂O, weight fraction of Cu, $WF_{Cu} = \frac{63.55}{170.48} = 0.3728$

3. For ZnCl₂, weight fraction of Zn, $WF_{Zn} = \frac{65.38}{136.29} = 0.4797$

4. For FeCl₃.6H₂O, weight fraction of Fe, $WF_{Fe} = \frac{55.85}{270.30} = 0.2066$

Let the mol % of MgO, CuO, ZnO in the MgCuZn Ferrites be x, y, and z respectively. For the stoichiometric composition, Fe₂O₃ is 50 mol % and x + y + z = 50 mol %. The number of mol of the oxides per mol of ferrites to be produced is as the following table:

Compound	Number of mol per mol of ferrite
MgO	0.02 x
CuO	0.02 y
ZnO	0.02 z
Iron oxide	1.00

Lets, W = Molecular weight

M = Molecular weight of the ferrites to be produced

$$M = 0.02 \{ W_{Mg} x + W_{Cu} y + W_{Zn} z \} + W_{Fe_2O_3}$$

$$M = 0.4862 x + 1.271 y + 1.3076 z + 175.7$$

C.) The theoretical weights of element for the production of 50g ferrites:

$$1. \text{ For Mg} = 50 \left[\frac{0.4862x}{M} \right]$$

$$2. \text{ For Cu} = 50 \left[\frac{1.271y}{M} \right]$$

$$3. \text{ For Zn} = 50 \left[\frac{1.3076z}{M} \right]$$

$$4. \text{ For Iron} = 50 \left[\frac{2(55.85)}{M} \right]$$

D.) Weight of corresponding chlorides:

$$1. \text{MgCl}_2 \cdot 6\text{H}_2\text{O} = \frac{50}{0.1196} \left[\frac{0.4862x}{M} \right] = 203.261 \left(\frac{x}{M} \right)$$

$$2. \text{CuCl}_2 \cdot 2\text{H}_2\text{O} = \frac{50}{0.3728} \left[\frac{1.271y}{M} \right] = 170.467 \left(\frac{y}{M} \right)$$

$$3. \text{ZnCl}_2 = \frac{50}{0.4797} \left[\frac{1.3076z}{M} \right] = 136.293 \left(\frac{z}{M} \right)$$

$$4. \text{FeCl}_3 \cdot 6\text{H}_2\text{O} = \frac{50}{0.2066} \left[\frac{2(55.85)}{M} \right] = \frac{27032.914}{M}$$

E.) Selection of suitable composition:

Based on literature review, the following composition was selected:

$x = 18 \text{ mol } \%$, $y = 12 \text{ mol } \%$ and $z = 20 \text{ mol } \%$

$\text{Mg}_{0.36} \text{Cu}_{0.24} \text{Zn}_{0.4} \text{Fe}_2\text{O}_4$ with $M = 225.8556 \text{ g/mol}$

In order to produce 50g ferrites, the following weight of chemical was used:

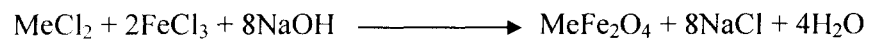
1. Weight of $\text{MgCl}_2 \cdot 6\text{H}_2\text{O} = 16.199 \text{ g}$

2. Weight of $\text{CuCl}_2 \cdot 2\text{H}_2\text{O} = 9.057 \text{ g}$

3. Weight of $\text{ZnCl}_2 = 12.069 \text{ g}$

4. Weight of $\text{FeCl}_3 \cdot 6\text{H}_2\text{O} = 119.691 \text{ g}$

F.) General reaction:



Which, Me refer to Mg, Zn and Cu.

$W_{\text{NaOH}} = 40 \text{ g/mol}$; $W_{\text{MeFe}_2\text{O}_4} = 328.94 \text{ g/mol}$

Specific gravity for NaOH, $S = 1.5 \text{ g/cc}$

Lets, $P =$ Number of mol of MeFe_2O_4 of 50 g sample.

Therefore,

Number of mole of NaOH required to make 50 g sample = 8P

Amount of NaOH required to make 50 g sample = 8P x W_{NaOH} = Y

$$P = \frac{50}{328.94} = 0.152 \text{ mol}$$

Amount of NaOH required to make 50 g sample, T = 8P x W_{NaOH}

$$T = 8 \times 0.152 \times 40$$

$$= 48.64 \text{ g}$$

$$\text{NaOH volume} = \frac{T}{S} = \frac{48.64 \text{ g}}{1.5 \text{ g/cc}} = 32.427 \text{ cc}$$

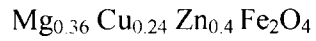
Notes: Solution of NaOH normally just 50 % by valume.

Therefore, Actual NaOH volume required = 32.427 x 2

$$= 64.854 \text{ cc}$$

APPENDIX B: Mixed oxide route

Selected chemical composition of ferrites:



Chemical	Molecular Weight, g / mol
MgO	40.30
CuO	79.55
ZnO	81.37
Fe ₂ O ₃	159.69

Notes: MW stand for Molecular Weight

The weight of individual oxide such as following:

$$1. \text{ Weight of MgO} = 0.36 \times \text{MW}_{\text{MgO}}$$

$$= 0.36 \times 40.30$$

$$= 14.508 \text{ g/mol}$$

$$2. \text{ Weight of CuO} = 0.24 \times \text{MW}_{\text{CuO}}$$

$$= 0.24 \times 79.55$$

$$= 19.092 \text{ g/mol}$$

$$3. \text{ Weight of ZnO} = 0.40 \times \text{MW}_{\text{ZnO}}$$

$$= 0.40 \times 81.37$$

$$= 32.548 \text{ g/mol}$$

$$4. \text{ Weight of Fe}_2\text{O}_3 = 159.69 \text{ g/mol}$$

$$\text{Total weight} = 225.838 \text{ g/mol}$$

50 g of ferrites required such as below:

$$\begin{aligned} 1. \text{ MgO} &= \frac{\text{Weight of MgO}}{\text{Total weight}} \times 50 \text{ g} \\ &= \frac{14.508}{225.838} \times 50 \text{ g} \\ &= 3.212 \text{ g} \end{aligned}$$

$$\begin{aligned} 2. \text{ CuO} &= \frac{\text{Weight of CuO}}{\text{Total weight}} \times 50 \text{ g} \\ &= \frac{19.092}{225.838} \times 50 \text{ g} \\ &= 4.227 \text{ g} \end{aligned}$$

$$\begin{aligned} 3. \text{ ZnO} &= \frac{\text{Weight of ZnO}}{\text{Total weight}} \times 50 \text{ g} \\ &= \frac{32.548}{225.838} \times 50 \text{ g} \\ &= 7.206 \text{ g} \end{aligned}$$

$$\begin{aligned} 4. \text{ Fe}_2\text{O}_3 &= \frac{\text{Weight of Fe}_2\text{O}_3}{\text{Total weight}} \times 50 \text{ g} \\ &= \frac{159.69}{225.838} \times 50 \text{ g} \\ &= 35.355 \text{ g} \end{aligned}$$

PUBLICATION

1. C. L. Chin, I. H. S. C. Metselaar, M. H. Koay, M. K. Lai, "Synthesis and Characterization of Magnesium-Copper-Zinc Ferrite by Co-Precipitation Process", Proceeding of the 2nd Technical Postgraduate Symposium, pp. 288-291, 2003.
2. C. L. Chin, I. H. S. C. Metselaar, M. H. Koay, M. K. Lai, "Densification and Electromagnetic Properties of Low Firing MgCuZn Ferrites", Proceedings of The Seventh Triennial AEESEAP Conference, pp. 305-310, 2003.
3. M. K. Lai, I. H. S. C. Metselaar, C. L. Chin, M. H. Koay, "Low Temperature Sintering of MgCuZn Ferrite With V₂O₅ Addition", Proceedings of The Seventh Triennial AEESEAP Conference, pp. 295-299, 2003.
4. M. K. Lai, I. H. S. C. Metselaar, C. L. Chin, M. H. Koay, "Effects of V₂O₅ Addition On MgCuZn Ferrite As Sintering Aid", Proceeding of the 2nd Technical Postgraduate Symposium, pp. 303-306, 2003.
5. M. H. Koay, I. H. S. C. Metselaar, M. K. Lai, C. L. Chin, "The Development And Analysis of Ternary Property-Diagrams On Magnesium-Copper-Zinc Ferrites", Proceedings of The Seventh Triennial AEESEAP Conference, pp. 265-269, 2003.
6. M. H. Koay, I. H. S. C. Metselaar, M. K. Lai, C. L. Chin, "Effect of Magnesium-Zinc Ratio On The Electromagnetic Properties of MgCuZn Ferrites", Proceeding of the 2nd Technical Postgraduate Symposium, pp. 297-301, 2003.