PennState College of Earth and Mineral Sciences

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Precipitation of Co-Mn from Low Concentration Solutions using Various Ligands and a Chemical-Free Process, A Case Study of Acid Mine Drainage (AMD)

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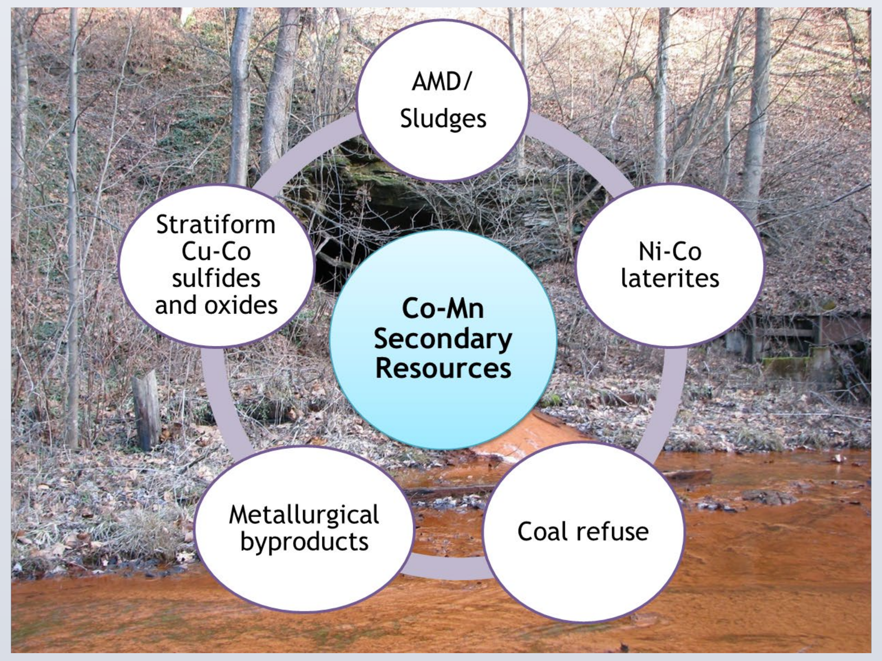
INTRODUCTION

- Cobalt (Co) and Manganese (Mn) are listed as critical elements by the U.S. Department of Interior.
- Major applications: rechargeable batteries, alloys, electric components, steel industry, chemical industry, ink, medicine.
- U.S. is currently 100% and 78% reliance on foreign sources of Mn and Co, respectively.
- Secondary resources:



- Acid Mine Drainage (AMD):

$$FeS_2 + \frac{7}{2}O_2 + H_2O \rightarrow Fe^{2+} + 2\,SO_4^{2-} + 2\,H^+$$

$$Fe^{2+} + \frac{1}{4}O_2 + H^+ \rightarrow Fe^{3+} + \frac{1}{2}H_2O$$

$$FeS_2 + 14\,Fe^{3+} + 8\,H_2O \rightarrow 15\,Fe^{2+} + 2\,SO_4^{2-} + 16\,H^+$$

- Pennsylvania has 5,500 miles of AMD streams
- AMD in the Appalachian region has been found to contain an elevated content of critical elements such as REEs, Al, Co, and Mn.
- The neutralization of AMD streams prior to discharge to the environment is mandatory under the Clean Water Act (U.S.C §1251).
- Co and Mn do not precipitate at circumneutral pH.
- Recovery of these elements from AMD while treating to address the environmental concerns improves the sustainability of the process.

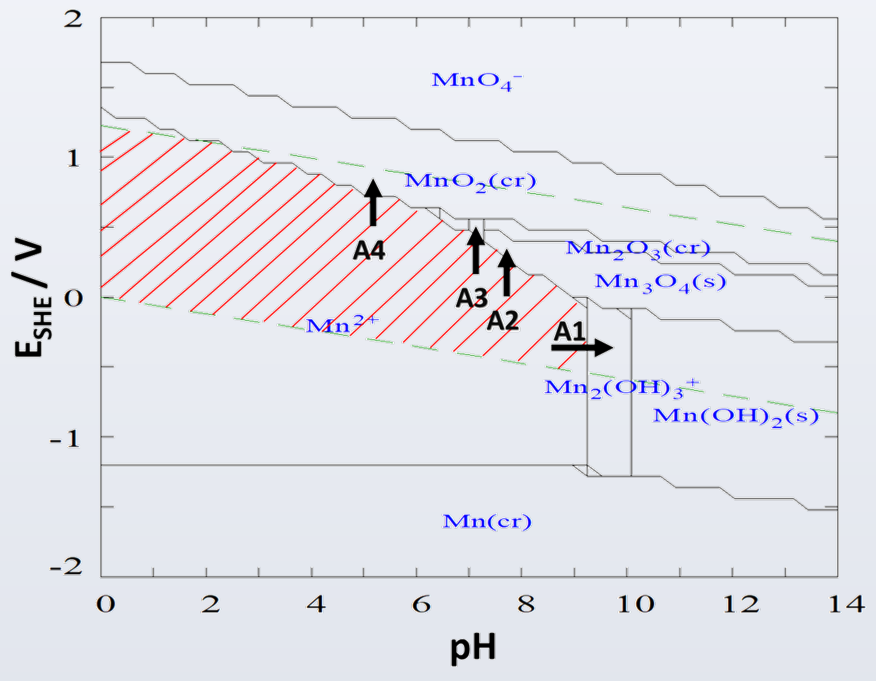
OBJECTIVE

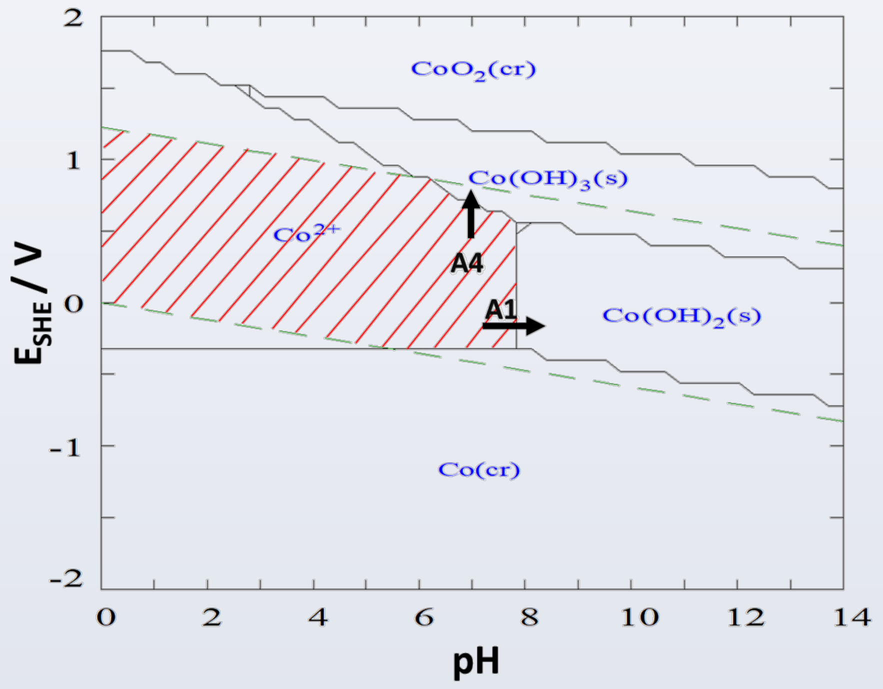
- To investigate the effect of various ligands and oxidation agents on precipitation of Co-Mn from low concentration solutions, and develop a process for recovery of these elements from AMD

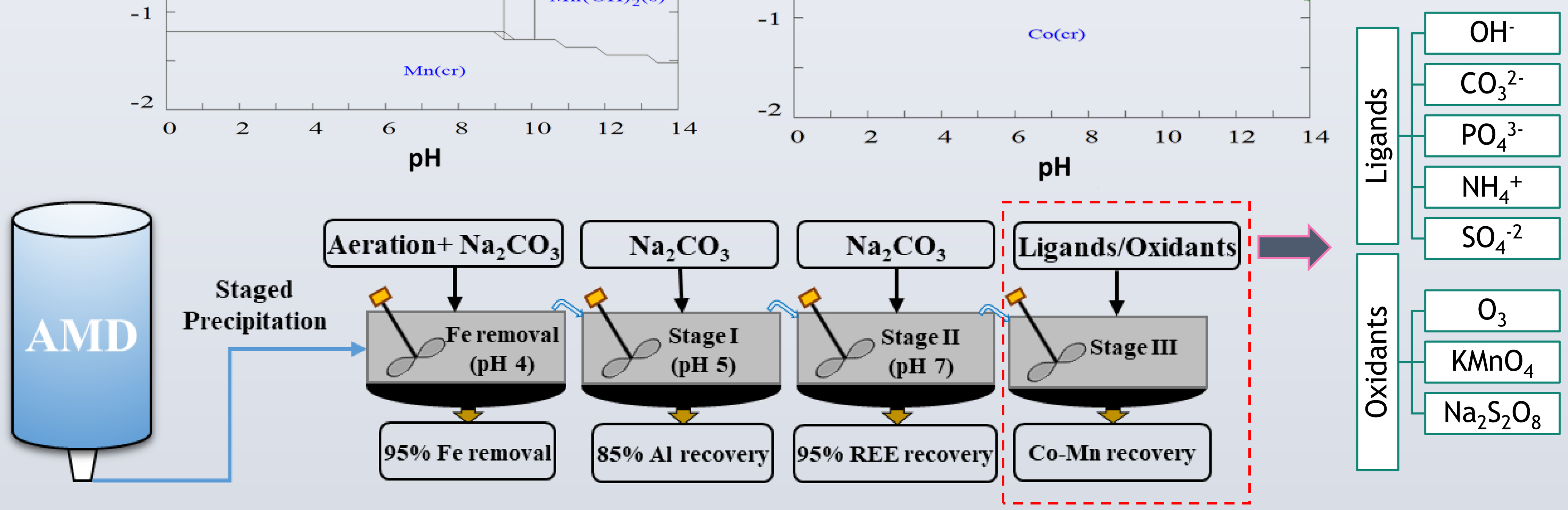
MATERIALS

Source	Elemental concentration (ppm)								
	Al	Fe	Mg	Mn	Co	Ni	Cu	Zn	TREE
AMD	45.6	4.7	399.8	**41.8**	**0.9**	1.6	0.1	3.1	0.5
Sludge	90550	25725	104621	**49096**	**1325**	2371	607	5145	1143

METHODS

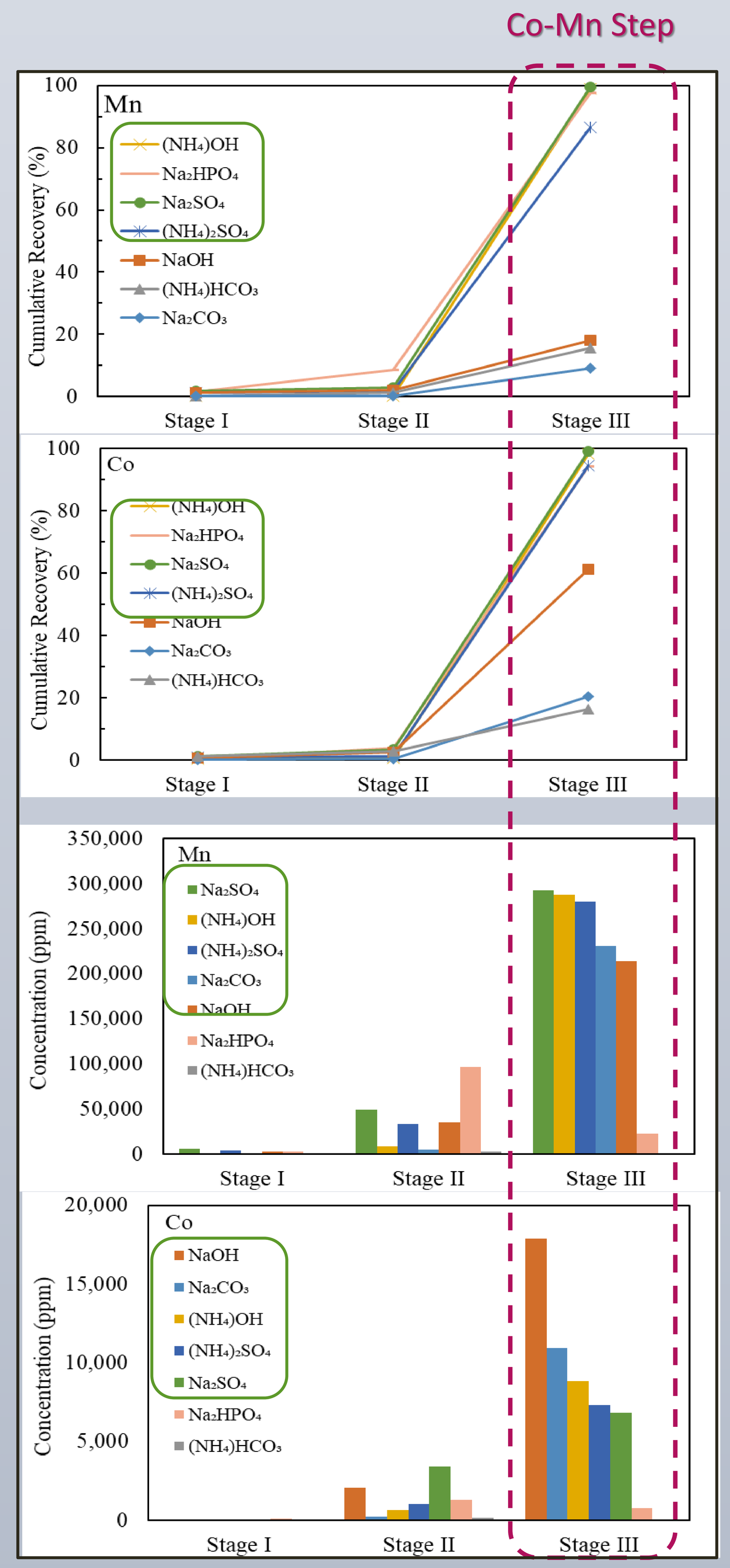




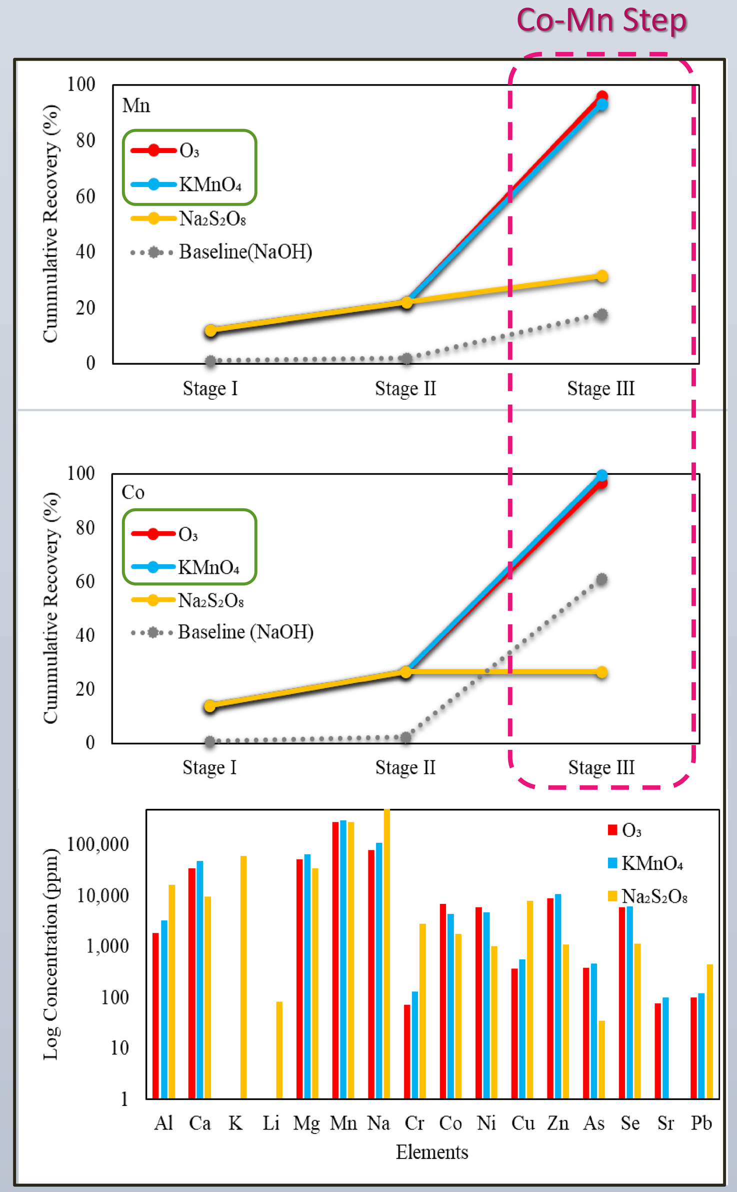


RESULTS AND DISCUSSION

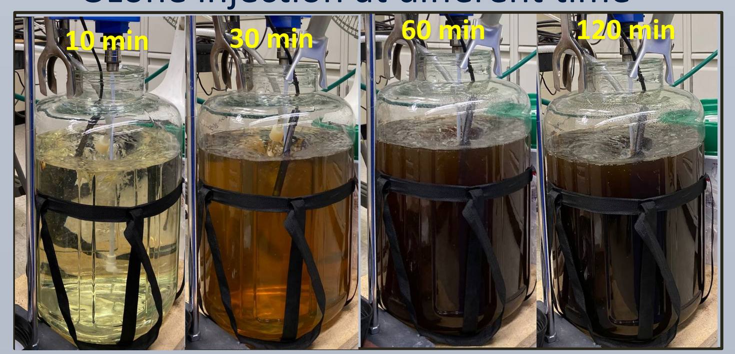
Ligand Precipitation



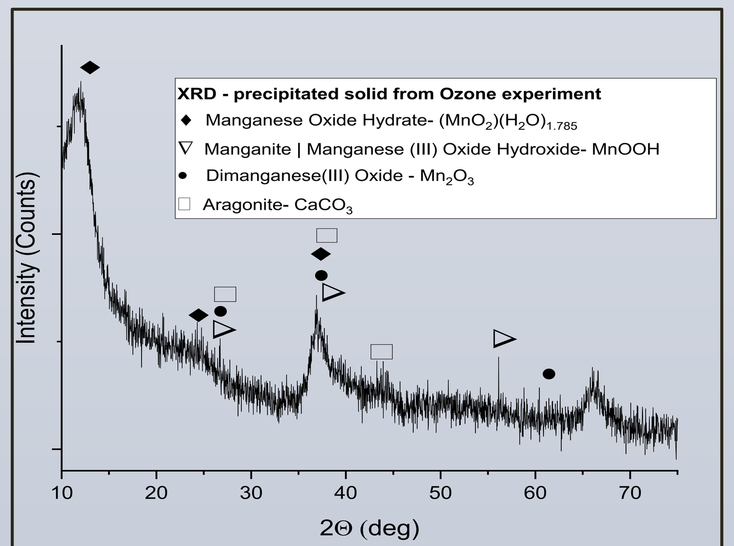
Oxidative Precipitation

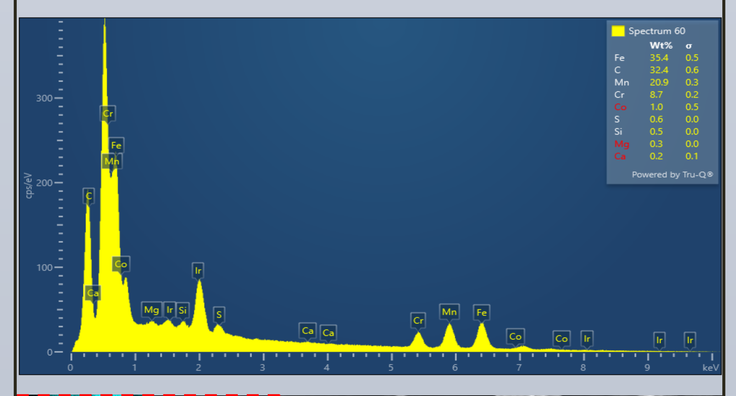


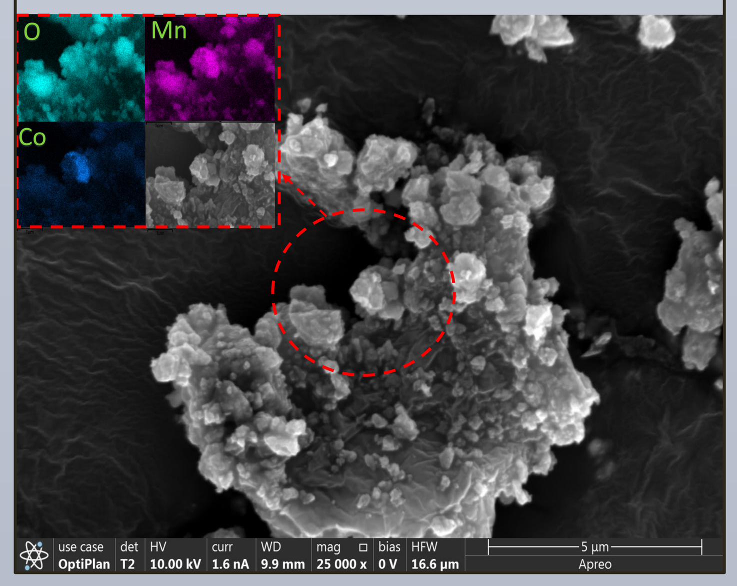
Ozone injection at different time



Characterization







- Ozone (O3) is one of the most effective oxidizing agents with an oxidizing potential of 2.07.
- It offers a chemical-free and environmentally friendly oxidative precipitation of Co-Mn through the following precipitation reaction paths:

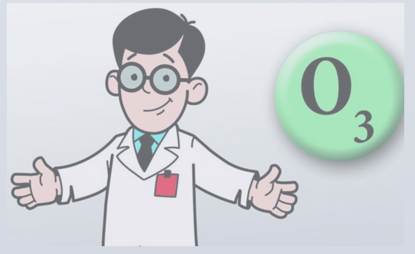
$$Mn^{2+} + 1/2O_3 + H_2O = 1/2Mn_2O_3 + 2H^+ + 1/2O_2 \quad (1)$$

$$Mn^{2+} + O_3 + H_2O = MnO_2 + 2H^+ + O_2 \quad (2)$$

$$Co^{2+} + 1/2O_3 + 3/2H_2O = CoOOH + 2H^+ + 1/2O_2 \quad (3)$$

CONCLUSIONS

- High recovery value for Co-Mn achieved by NH_4^+, SO_4^{-2}, and PO_4^{3-} ligands at pH 9.
- Among the oxidation agents, ozone resulted in the highest recovery/grade for Mn (98%/29%) and Co (99%/0.8%).
- In the proposed staged precipitation process, more than 95% of Co-Mn, 95% of REE, and 85% of Al were recovered.



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