Universidad Autónoma de Coahuila
Mathiesen México

Uso del D2020 como depresor de cobre: Efecto de iones Cu^{2+} en solución con tioles.

Que presenta
Ing. Hazel René Gallegos Moreno

XXXVI Convención Internacional de Minería Acapulco 2025
La minería unida por México

Noviembre 2025, Acapulco, Guerrero

Depresores de Cobre convencionales

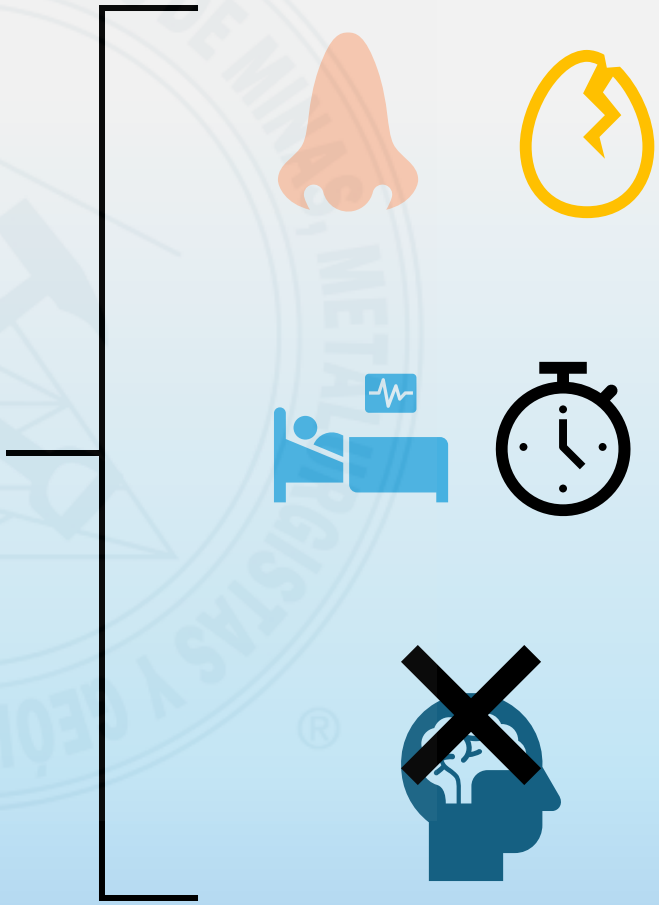
NaSH

$$NaSH + H_2O \leftrightarrow NaOH + H_2S$$

$$H_2S \leftrightarrow H^+ + HS^-$$

$$2CuX + HS^- \leftrightarrow Cu_2S + 2X^- + H^+$$

Yi y Col 2021



0.005 a 0.03 ppm

10 a 20 ppm por 8 horas

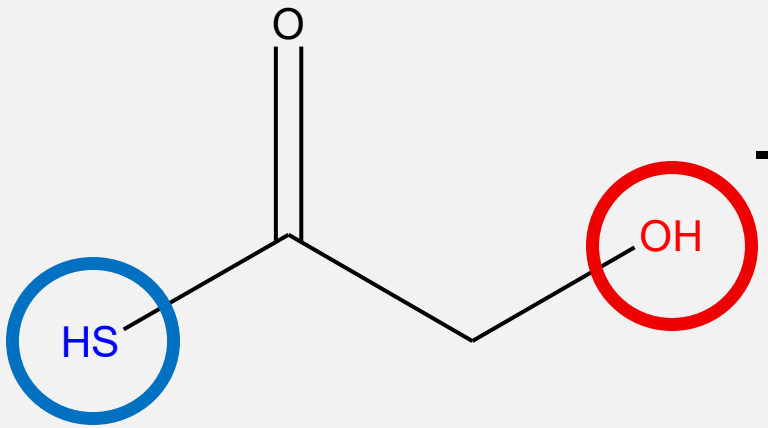
>20 ppm

>100 ppm

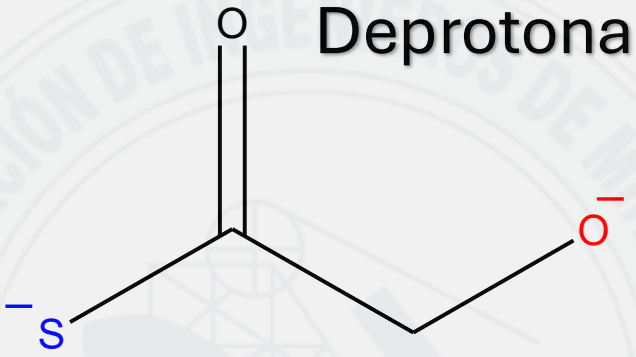
Occupational Safety and Health Administration (OSHA

Mecanismo de depresión de tioles

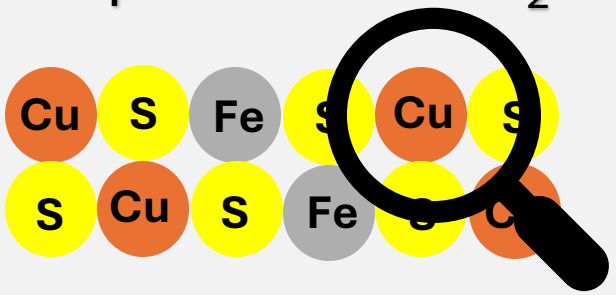
Ácido tioglicolico



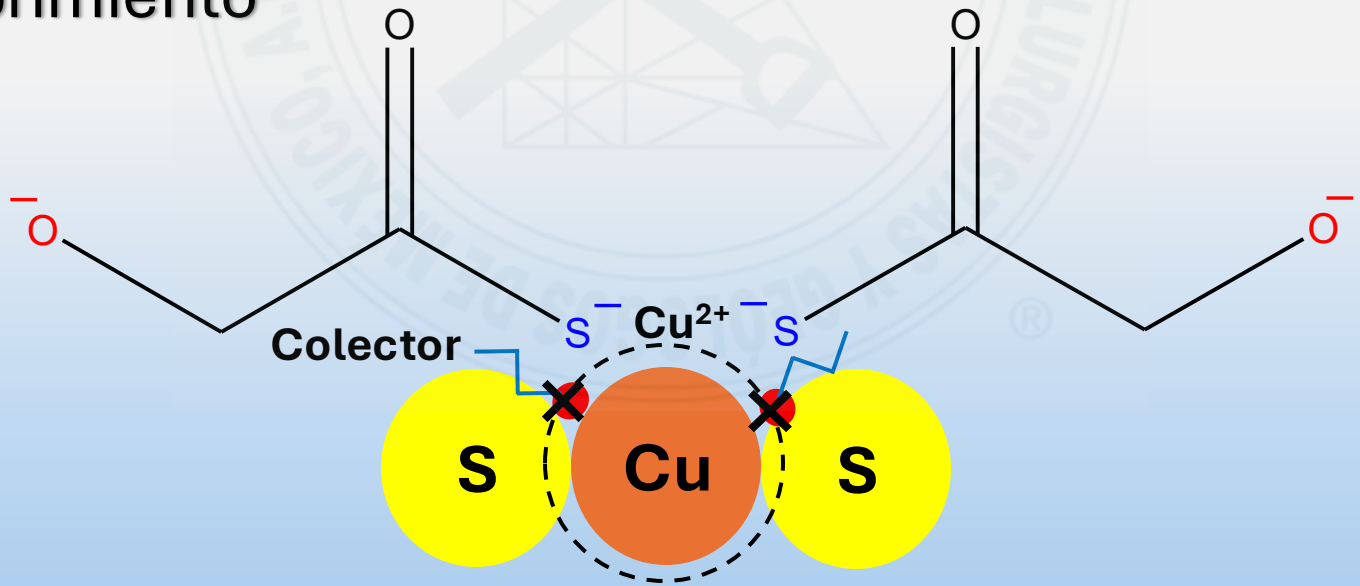
Deprotonación

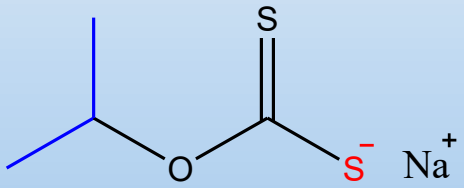


Superficie $CuFeS_2$



Recubrimiento



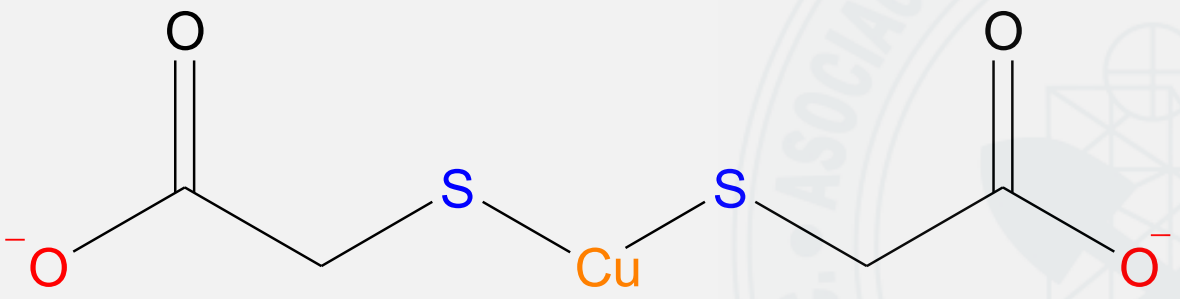


Xantatos

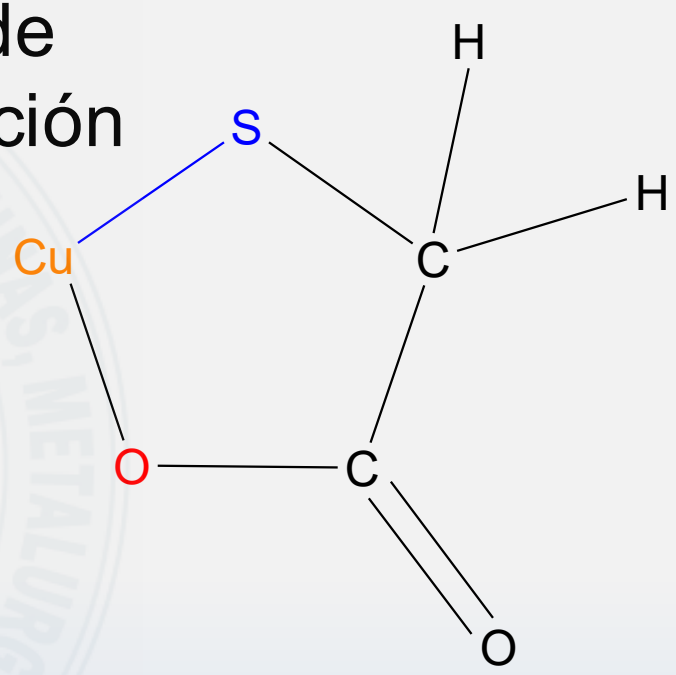
Liu Qi 1982

Mecanismo de depresión

Iones Tiolato



Anillo de coordinación



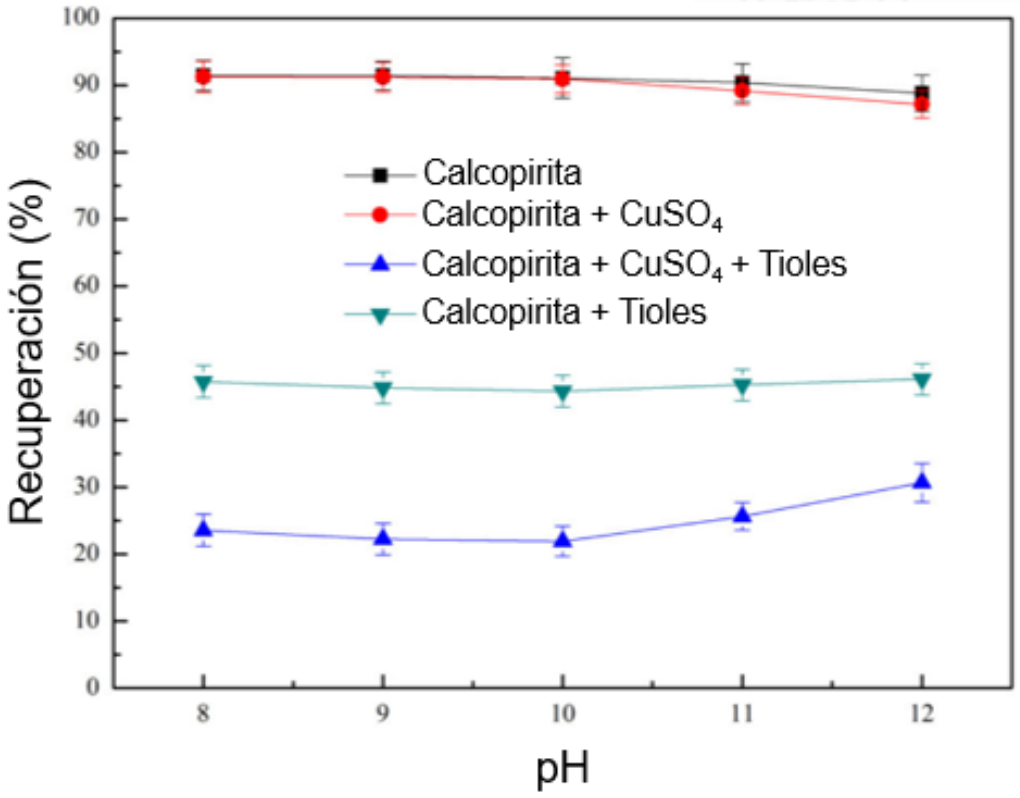
$$Cu^{2+} + 2HSCH_2COO^- \rightarrow [Cu(SCH_2COO)_2]^{2-}$$

$$SCH_2COO^{-2} + Cu^{+2} \rightarrow [Cu(SCH_2COO)]$$

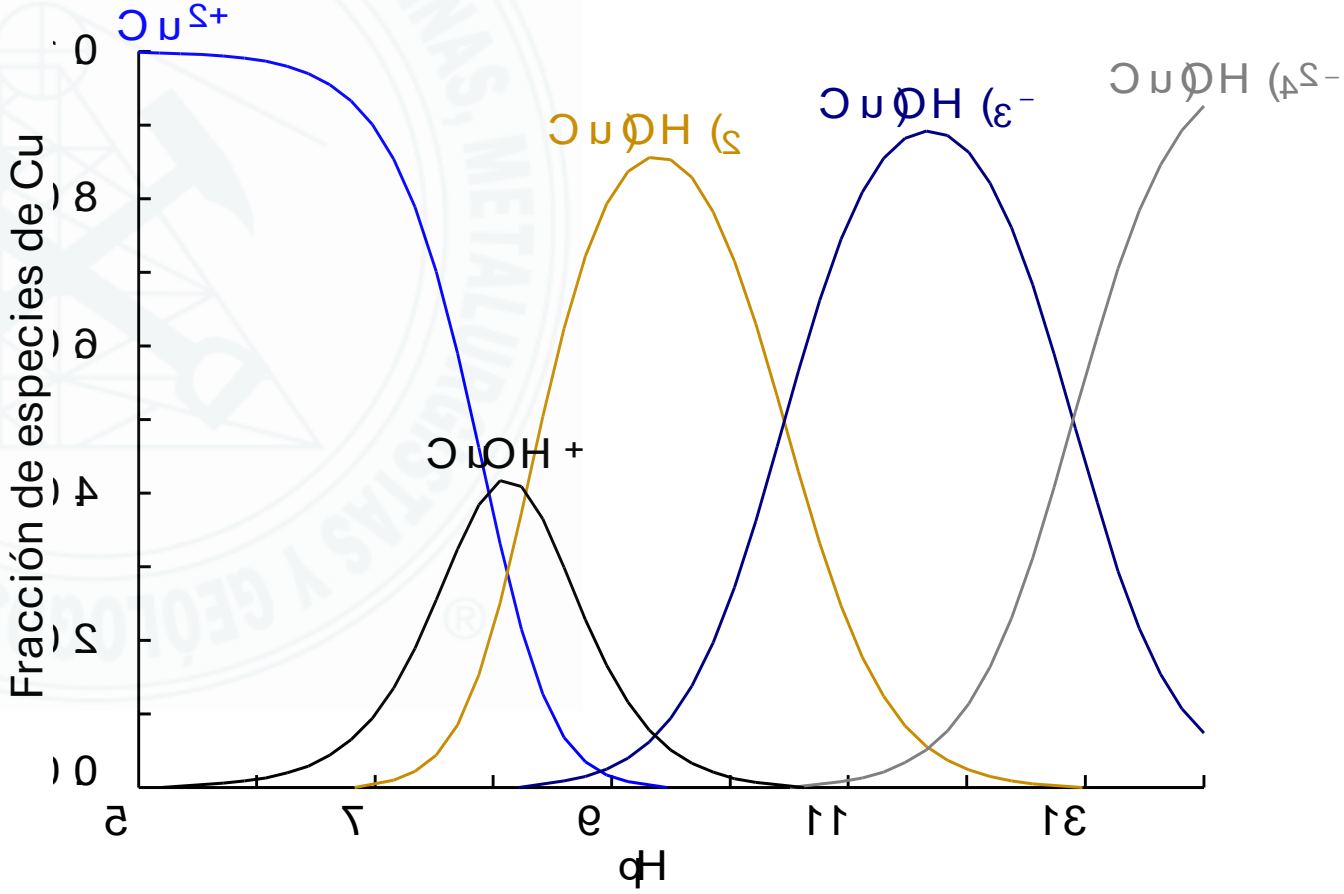
Wenqing y Col 2017

Efecto de Iones Cu^{2+}

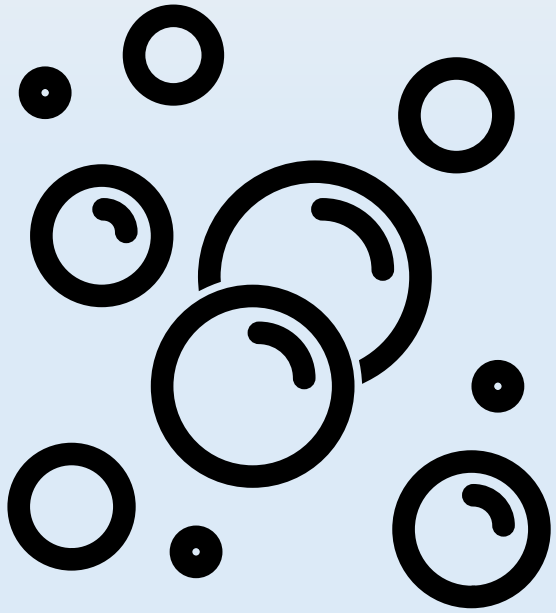
Zhang y col, 2020

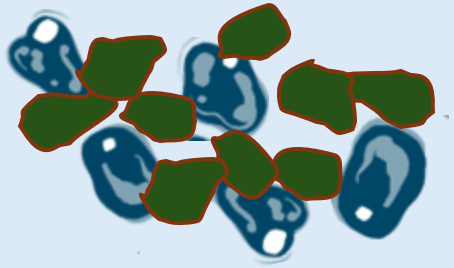


Jiang y col, 2025



Condiciones





pH: 8.5 - 11
ORP: -450 eV

Acondicionamiento
7 minutos
Flotación
5 minutos

Velocidad
1000 rpm

Paleteo
10 segundos

Sólidos
30%

Dosificación
6-11 kg/ton

Diseños experimentales

Flotación Primaria

Prueba	Dosificación (kg/ton)	pH
1	8	6
2	6	6
3	8	9
4	6	9

Efecto del ion Cu^{2+}

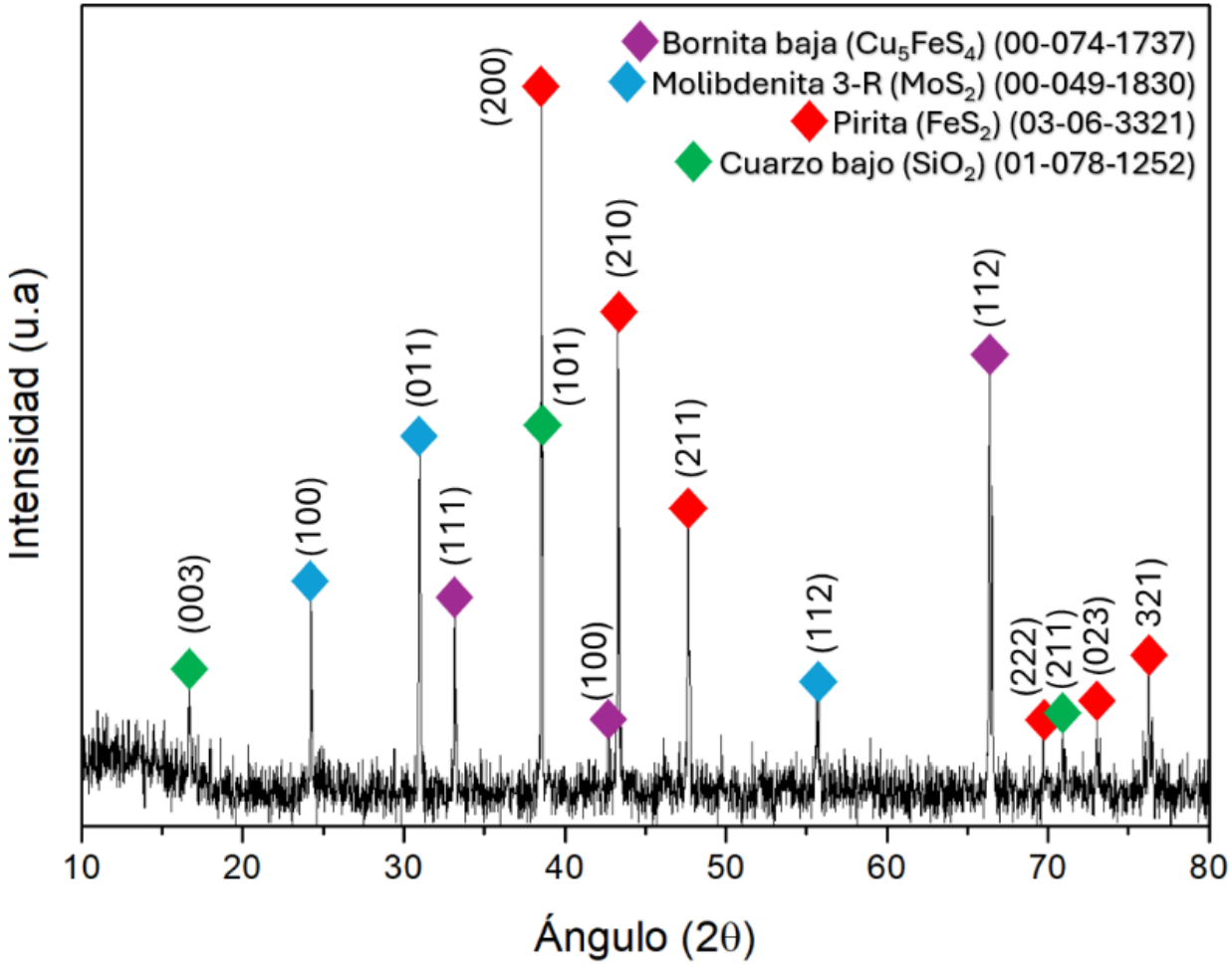
Prueba	Dosificación (kg/ton)	$CuSO_4$ [M]	pH
STD	9	-	11
1	9	$1X10^{-3}$	8
2	11	$1X10^{-3}$	8
3	9	$1.5X10^{-3}$	8
4	11	$1.5X10^{-3}$	8
5	9	$1X10^{-3}$	11
6	11	$1X10^{-3}$	11
7	9	$1.5X10^{-3}$	11
8	11	$1.5X10^{-3}$	11

Cinética

Tiempo (min)	1	2	4	8	16
N.A					
$CuSO_4$ [M] $1X10^{-3}$					

Caracterización

Difracción de rayos X



Espectroscopia de Absorción Atómica (AA)

DOE 2^2 Flotación primaria

Elemento	Cu	Mo	Fe	Zn	As
%	0.92	0.17	9.11	0.4	0.03

DOE 2^3 Flotación efecto Cu^{2+}

Elemento	Cu	Mo	Fe	Zn	As
%	23.4	0.58	24.10	1.7	0.98

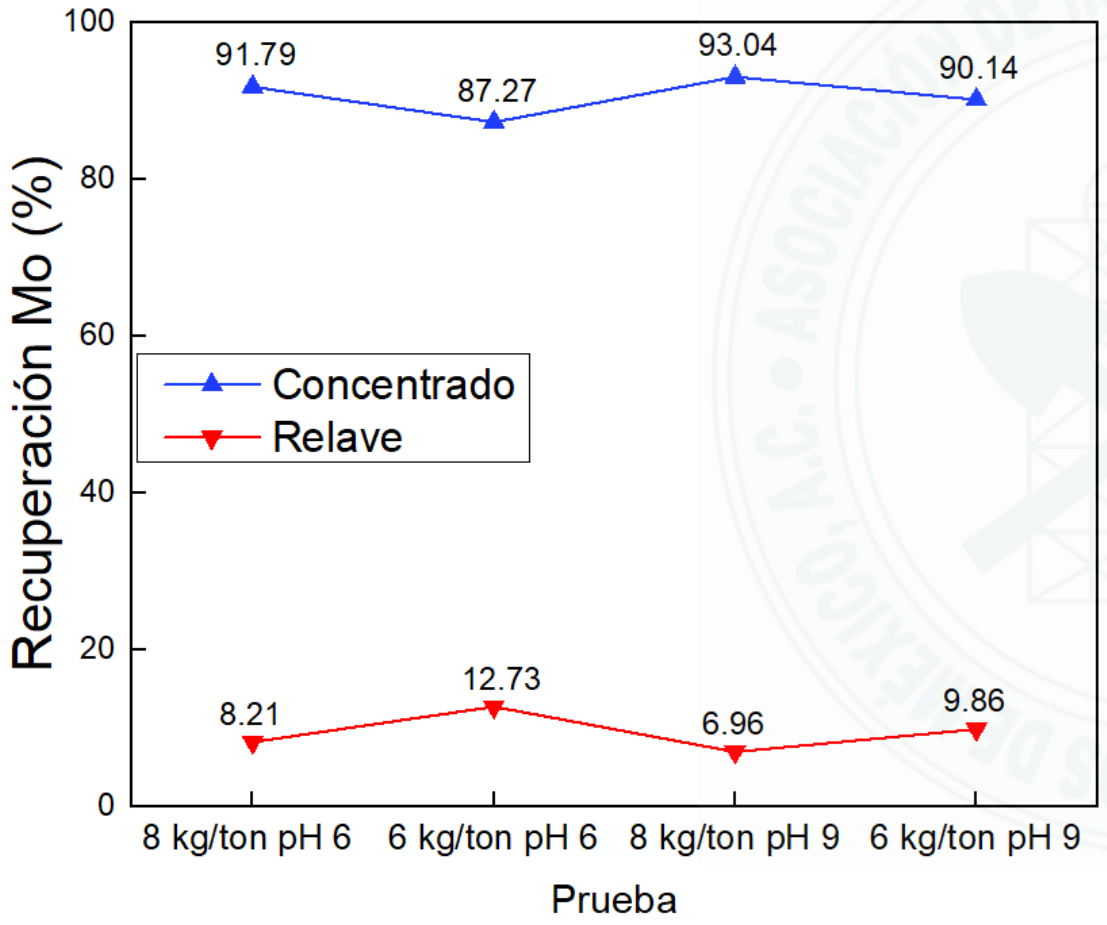
DOE 2^3 Cinética de flotación

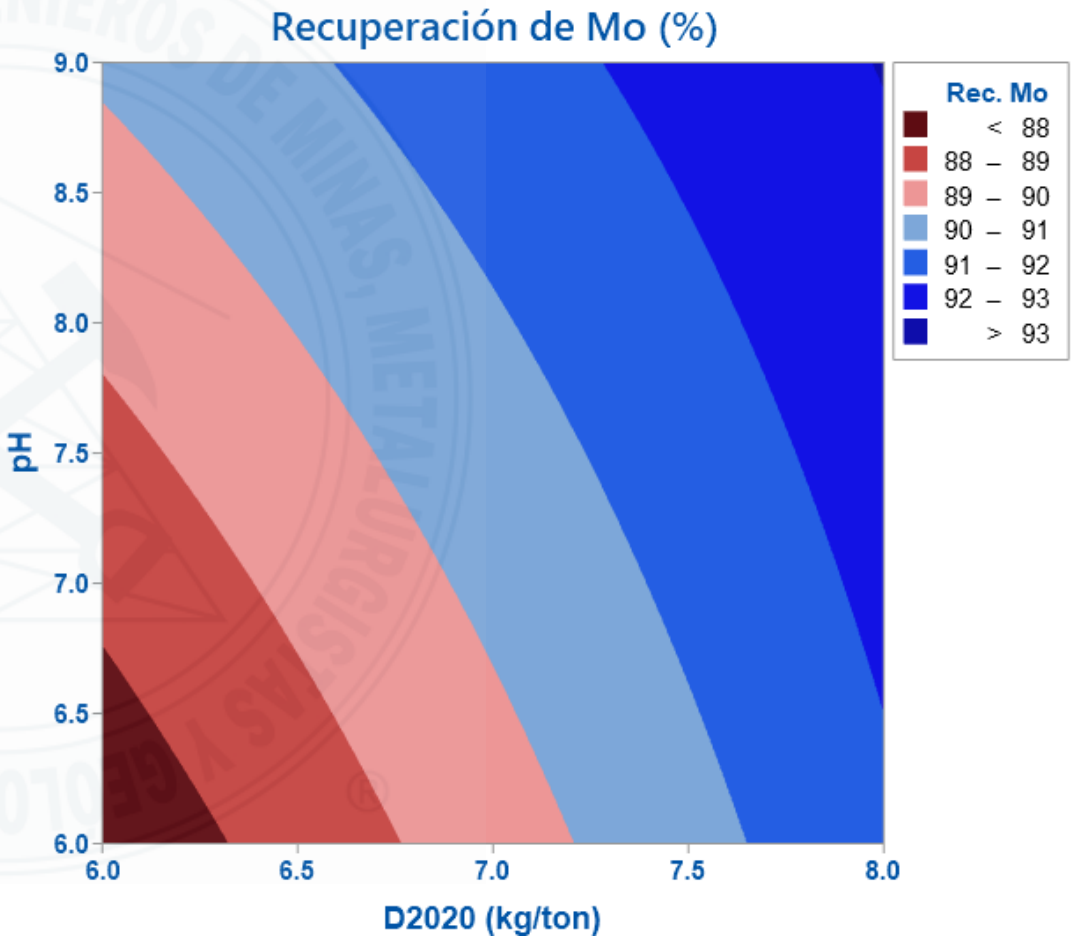
Elemento	Cu	Mo	Fe	Zn	As
%	20.1	0.81	23.70	2.2	0.85

Resultados

Flotación D-2020

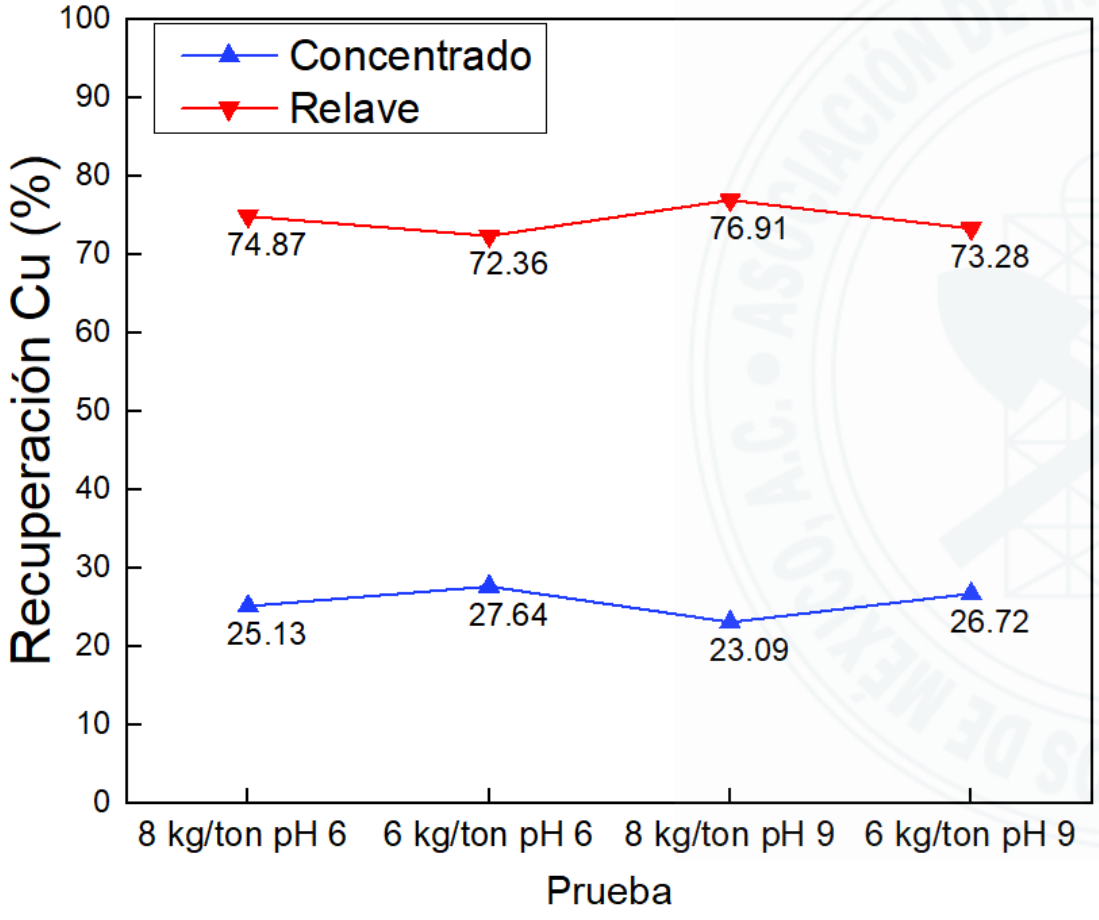
Recuperación Mo

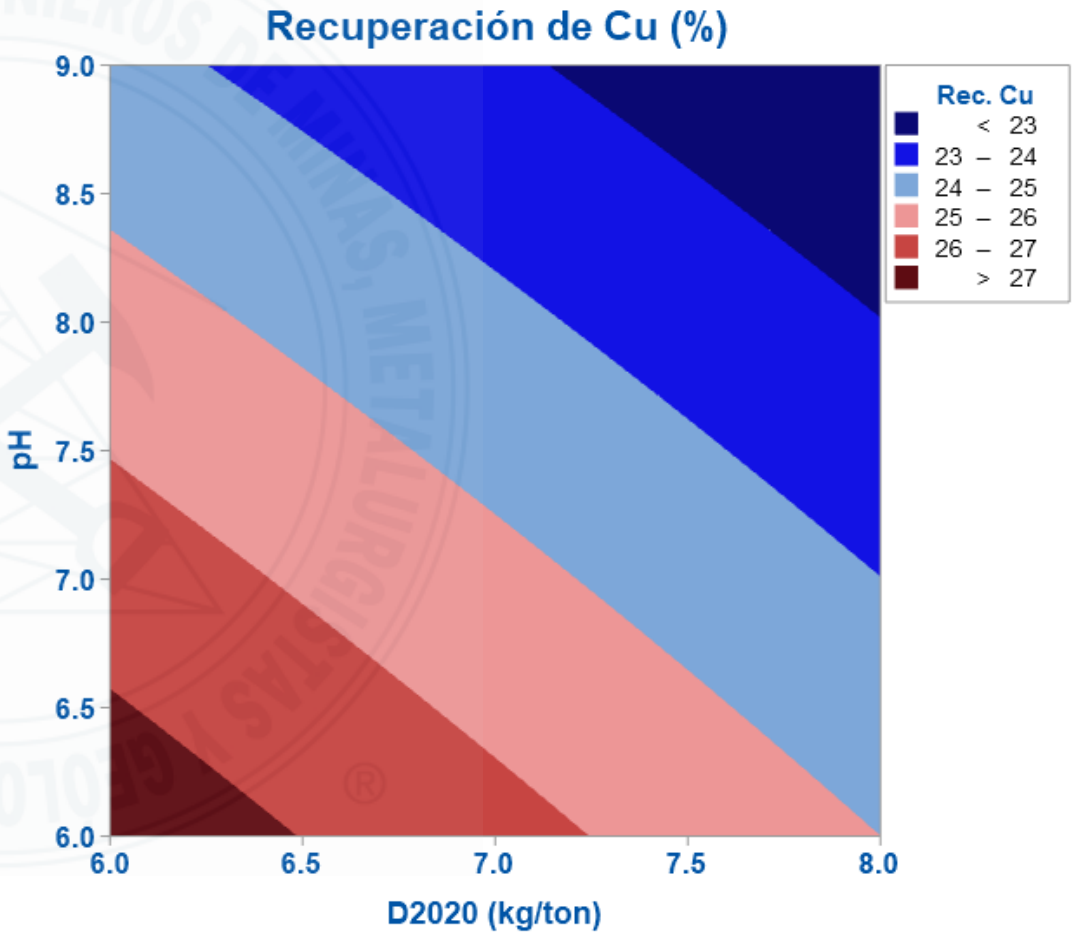




Flotación D-2020

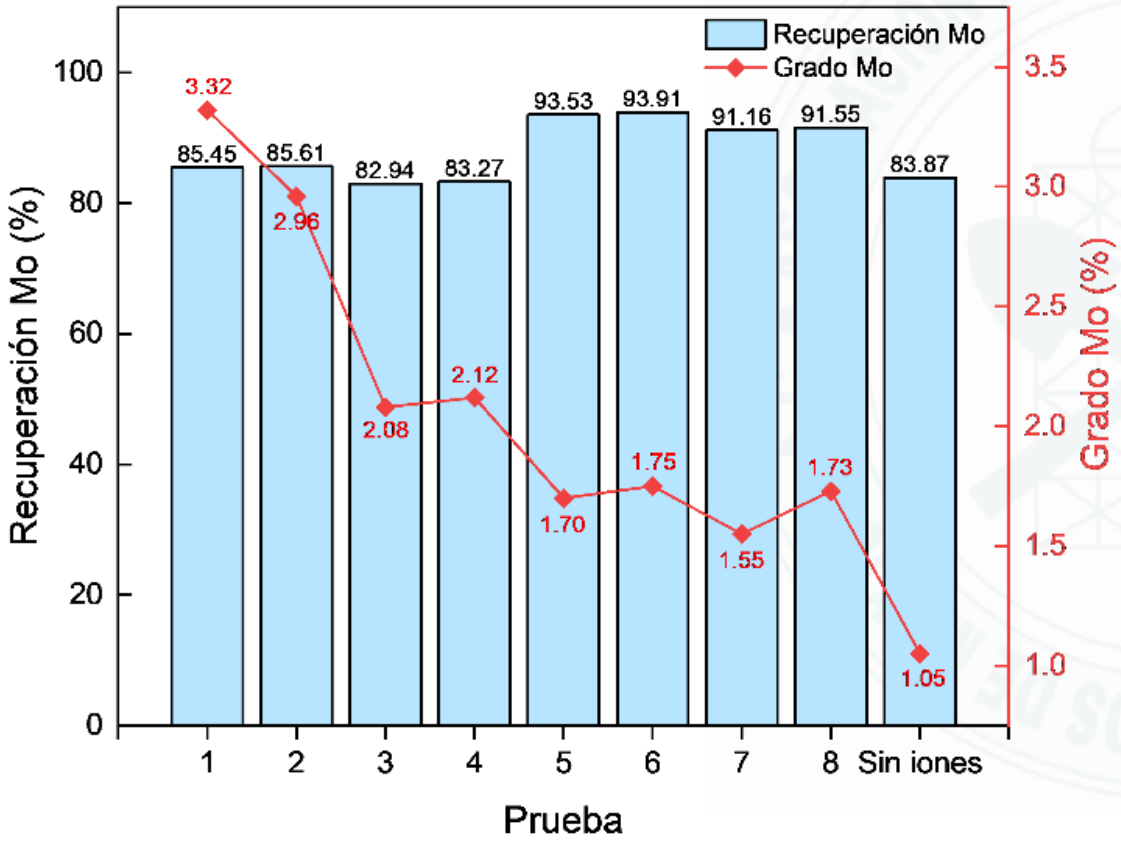
Recuperación Cu

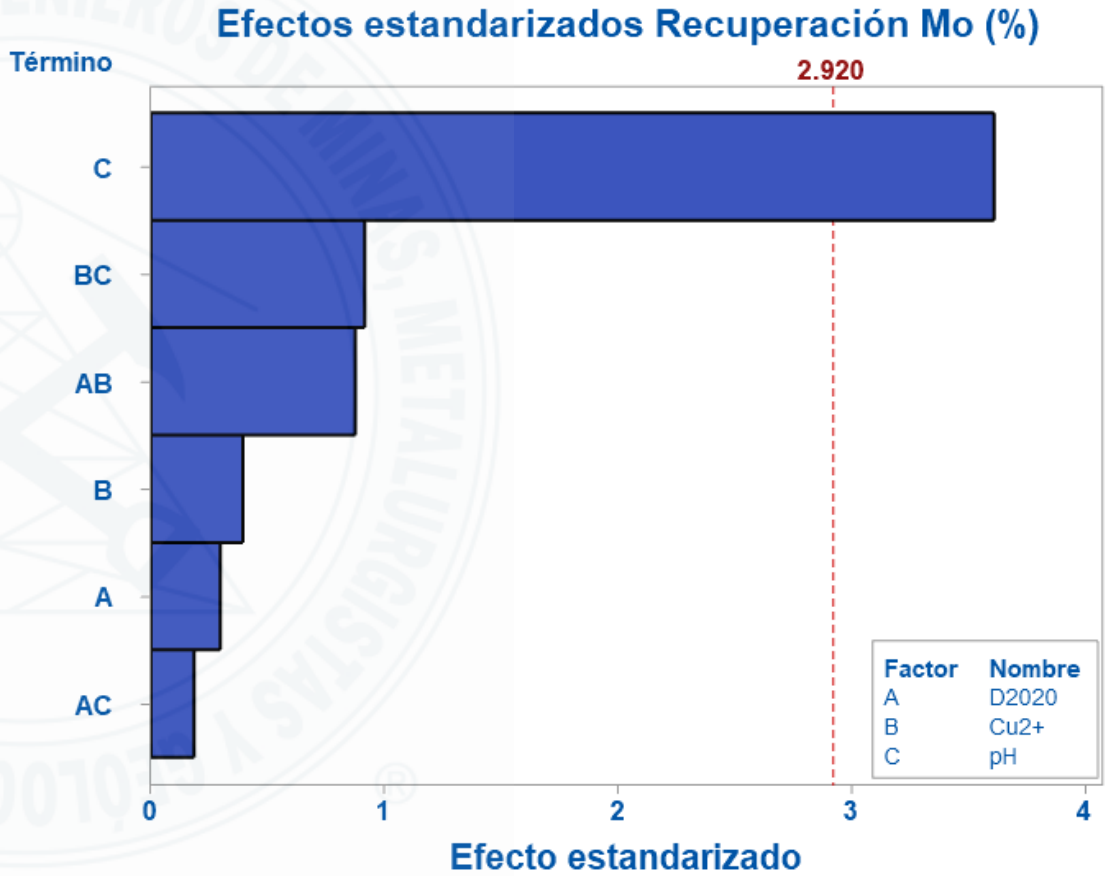




Flotación D-2020 + Cu^{2+}

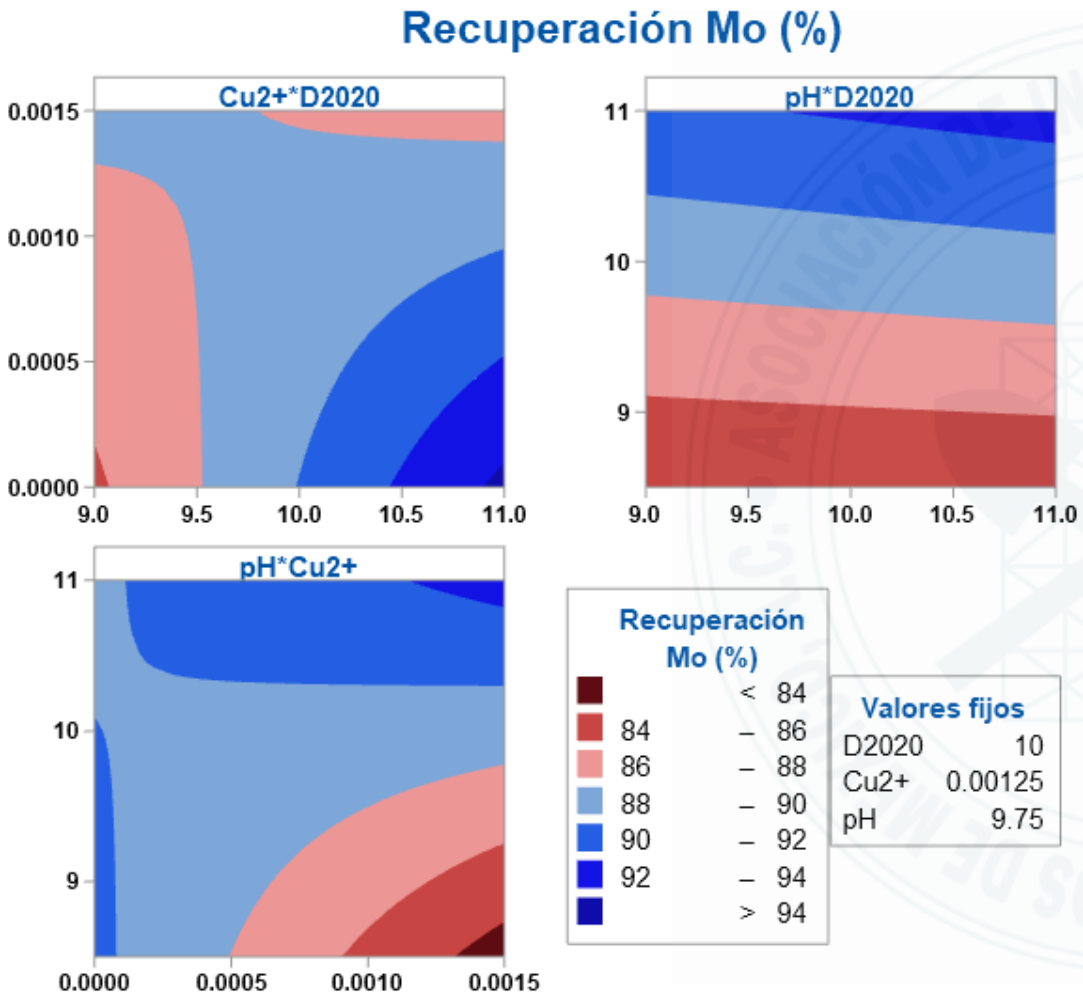
Grado y Recuperación Mo

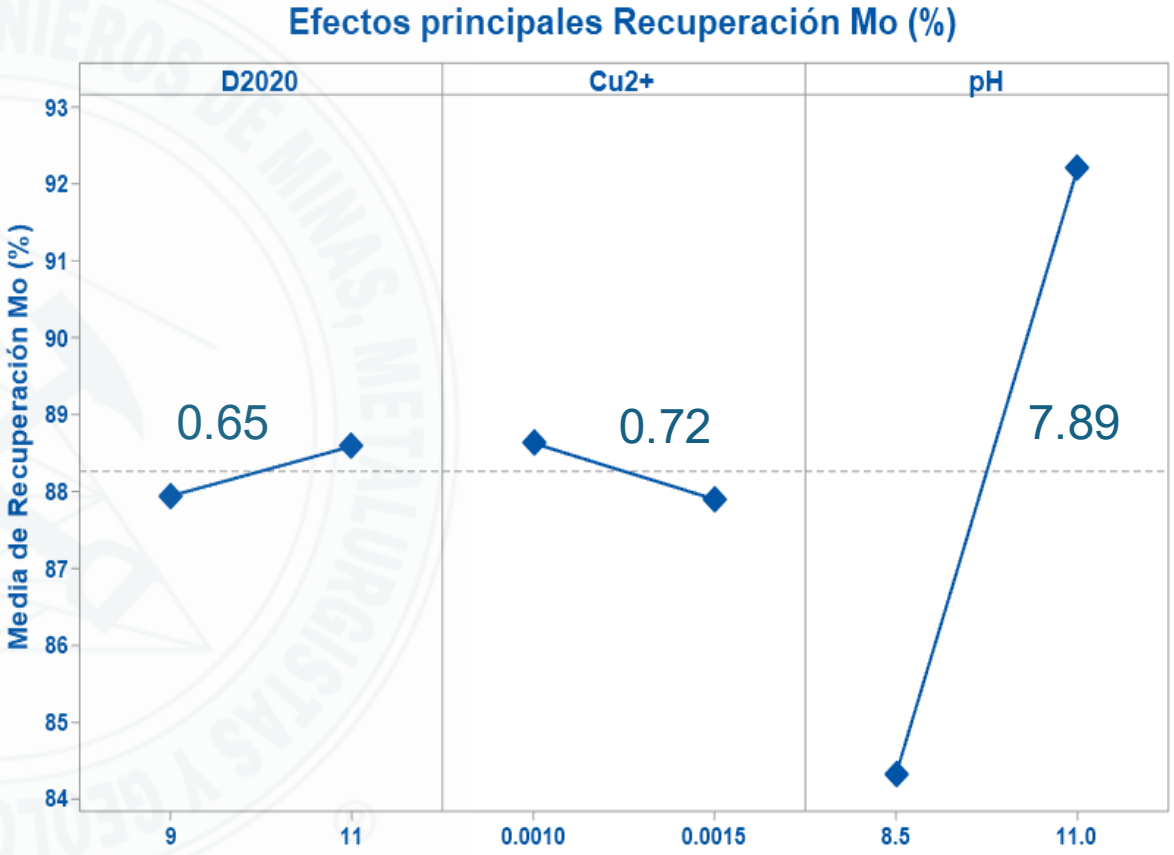




El pH es el factor con una significancia estadística (C)

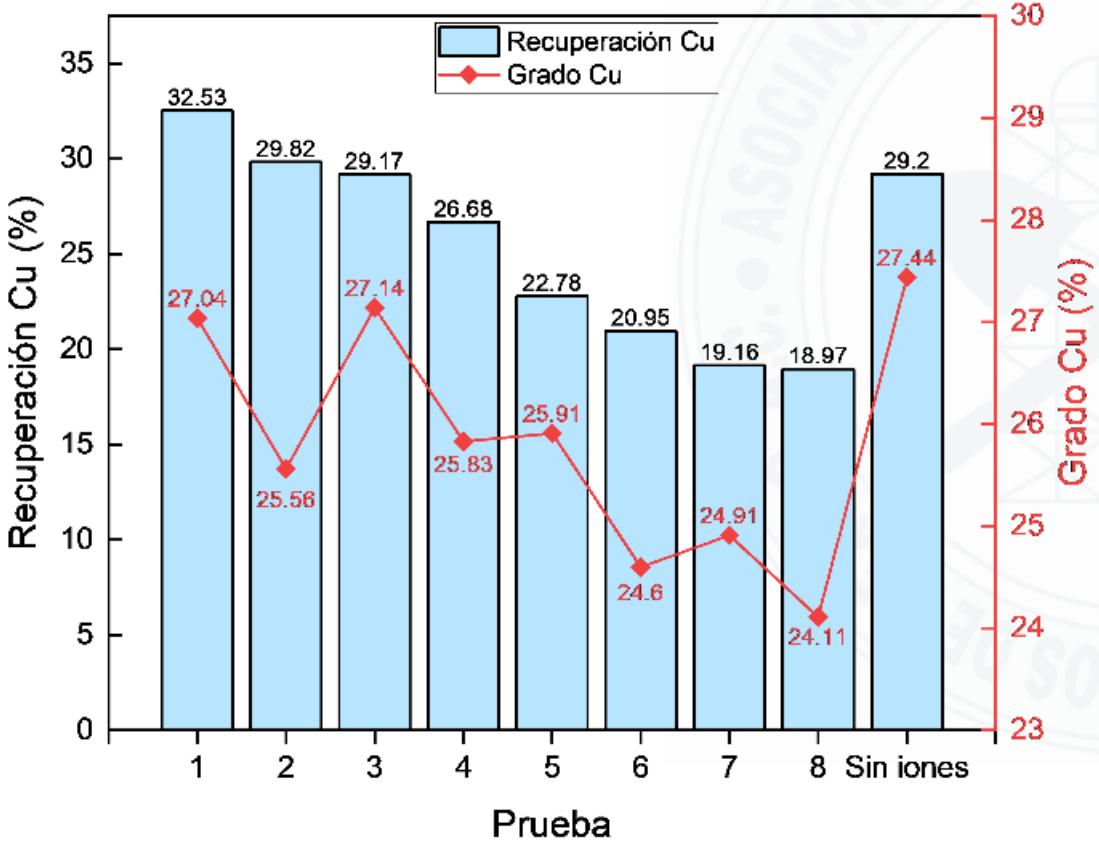
Flotación D-2020 + Cu^{2+}

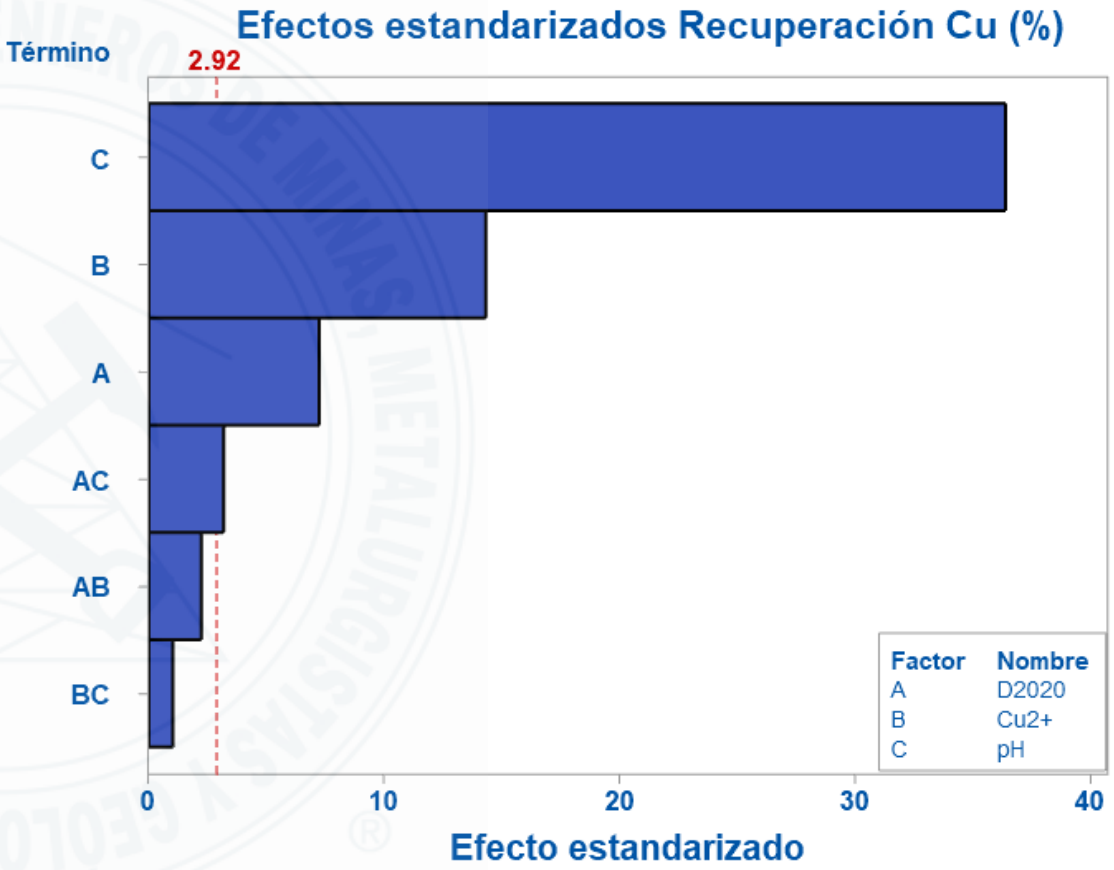




Flotación D-2020 + Cu^{2+}

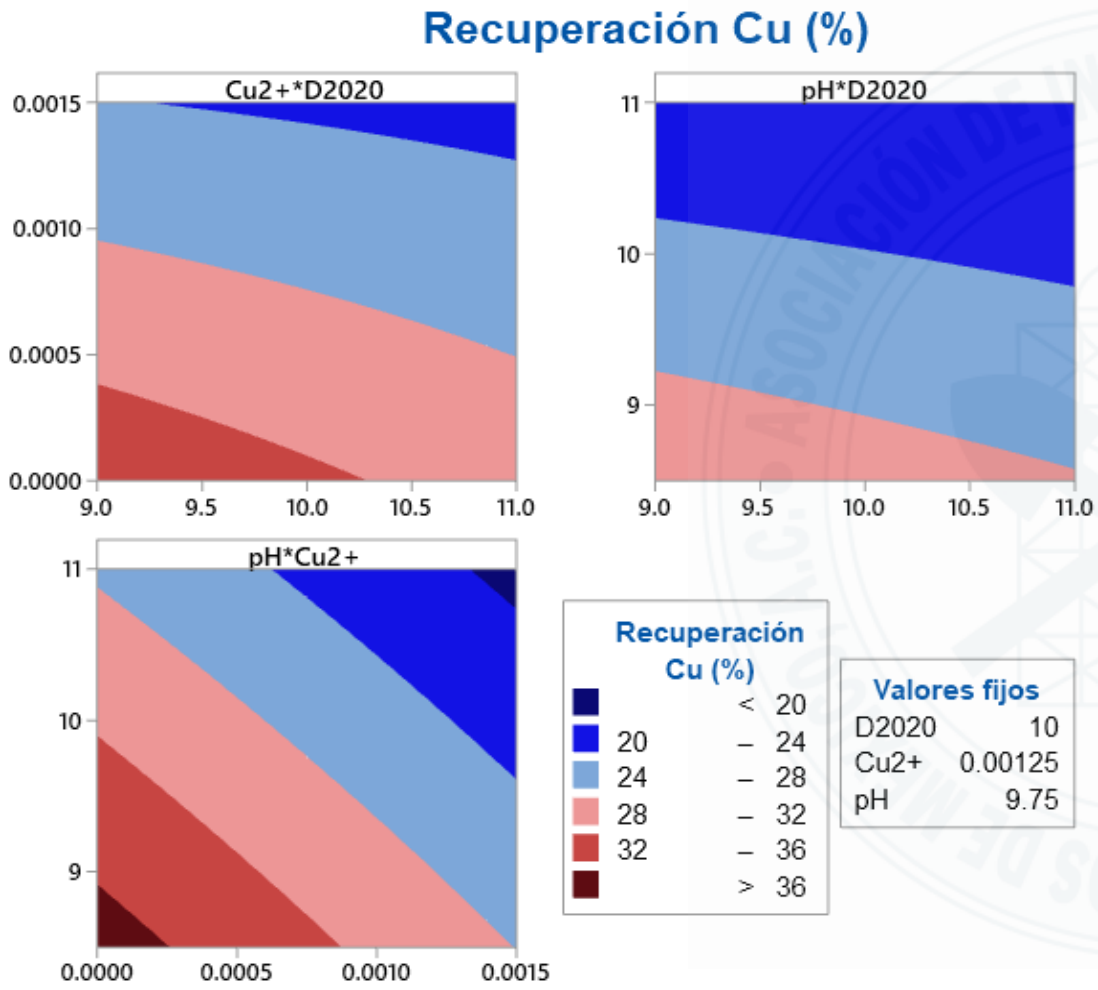
Grado y Recuperación Cu

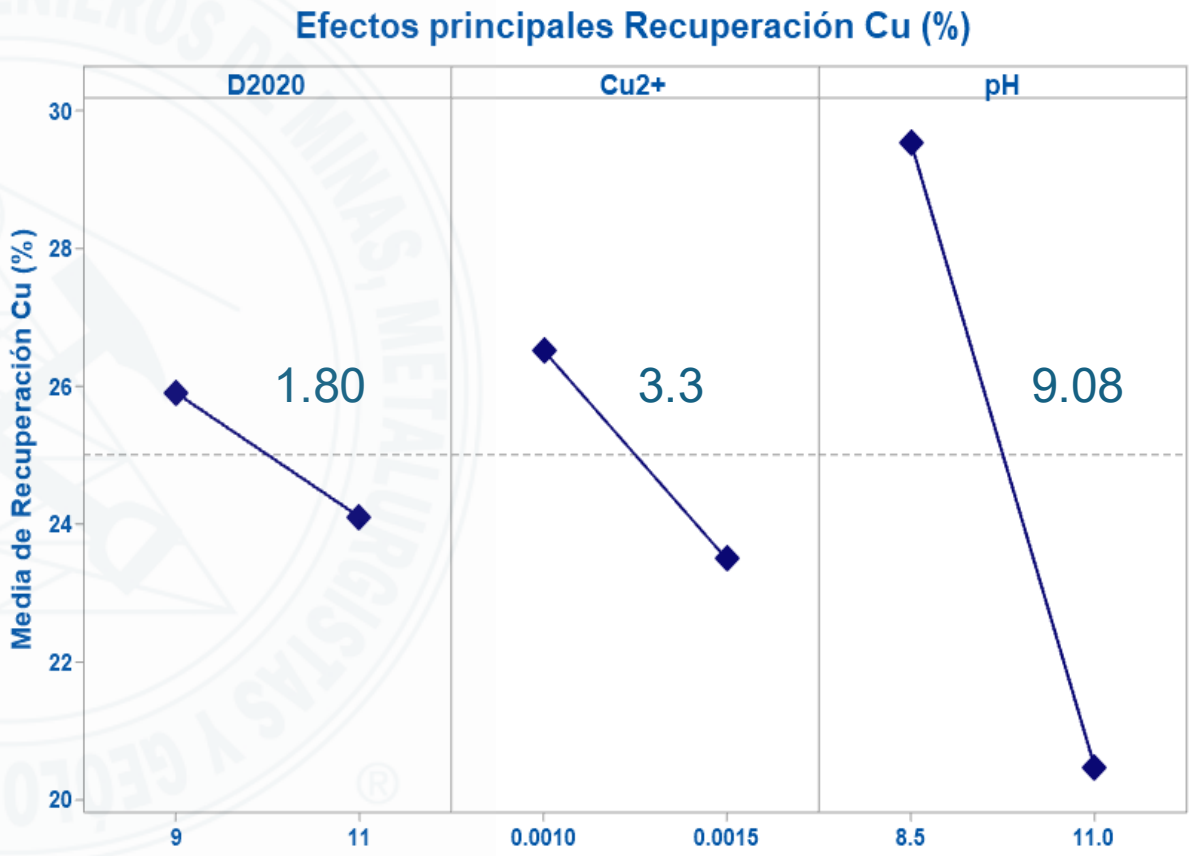




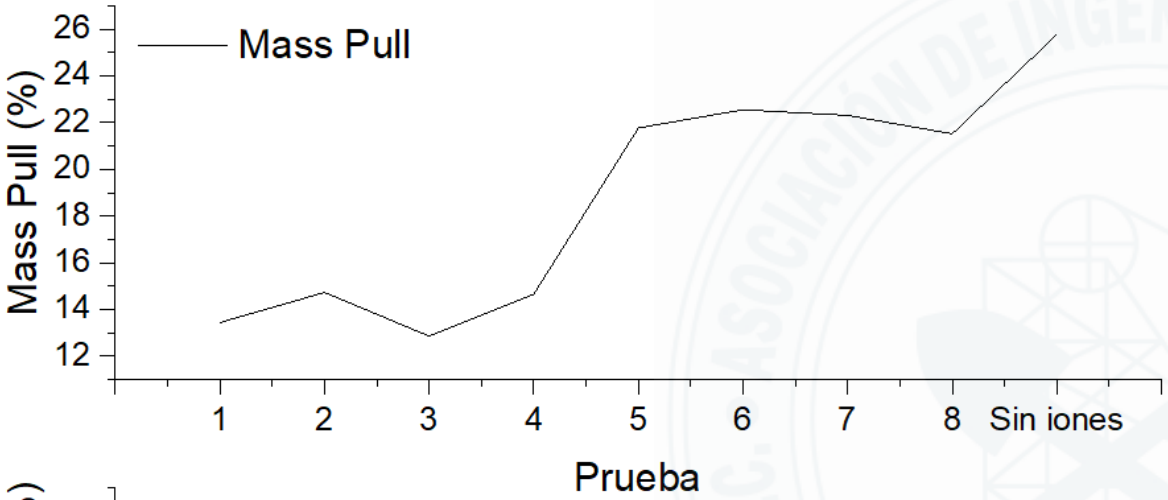
El pH, Cu^{2+}, D2020 son los factores significativos y la interacción entre el D2020 y el pH

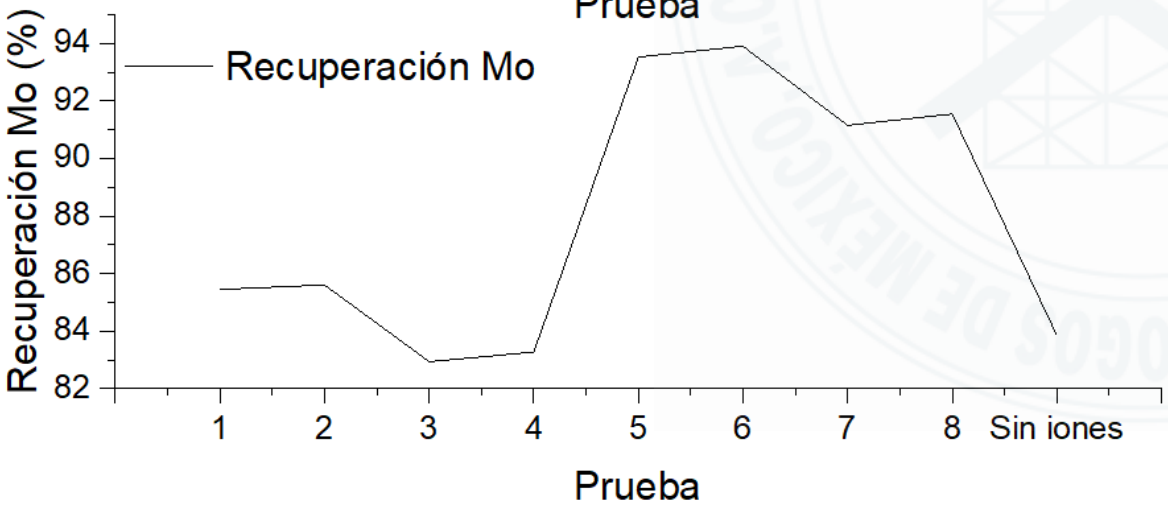
Flotación D-2020 + Cu^{2+}

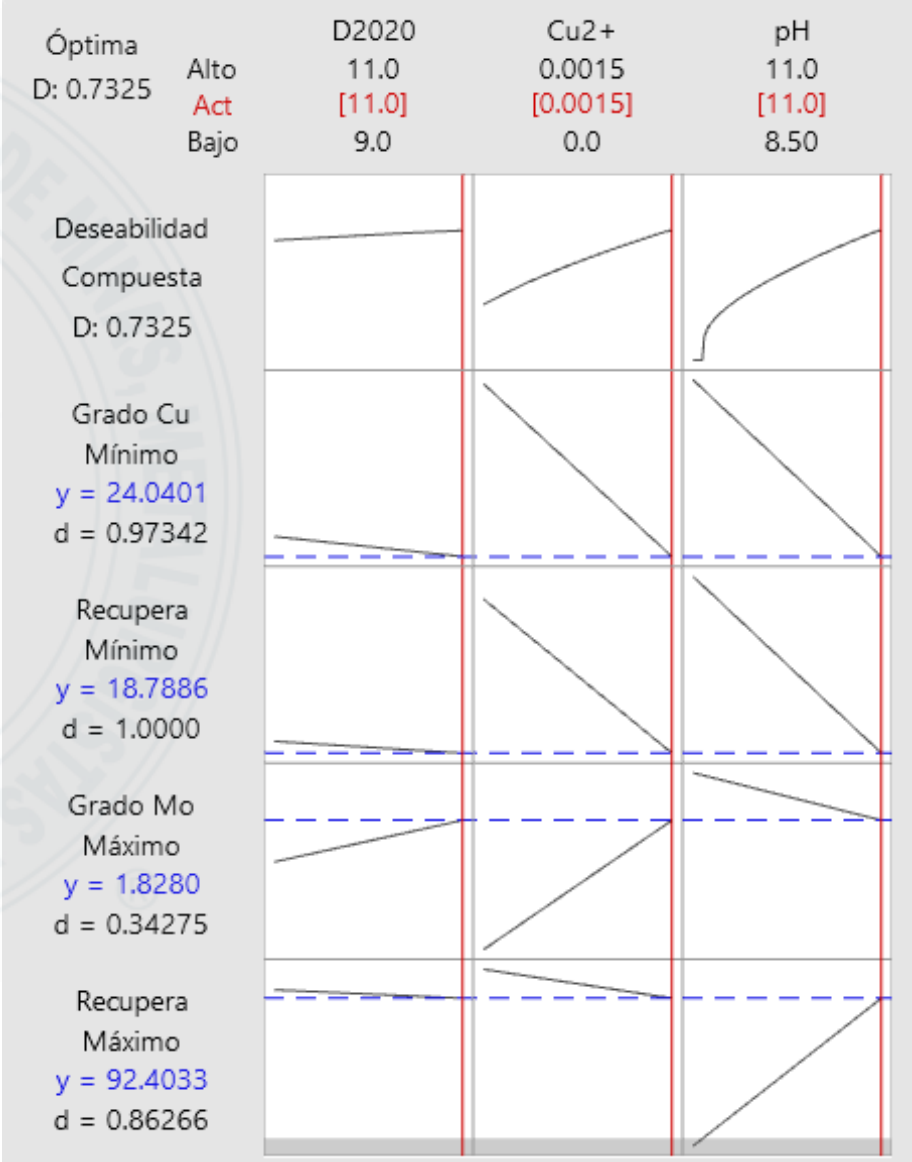




Optimización de respuesta

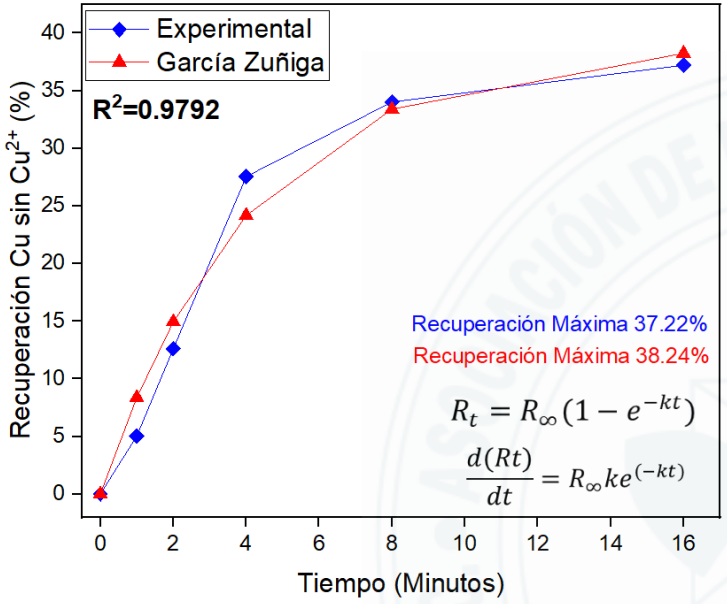


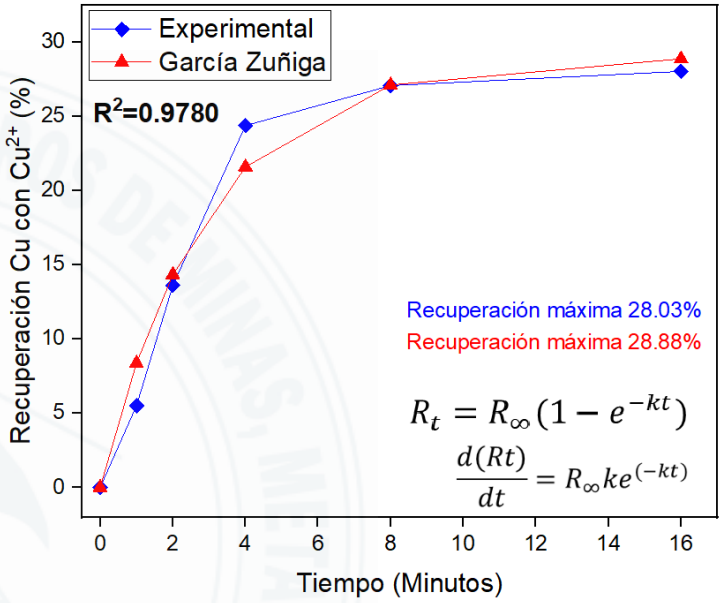




Cinéticas

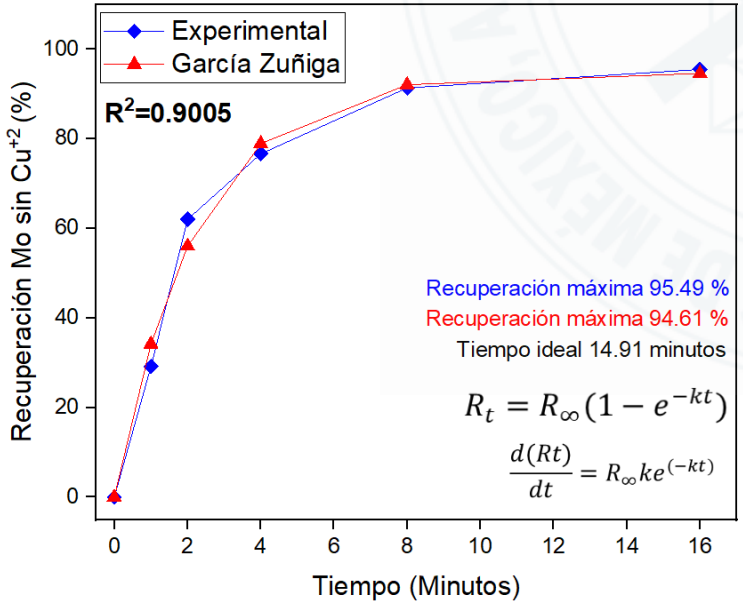
Cobre sin iones Cu^{2+}

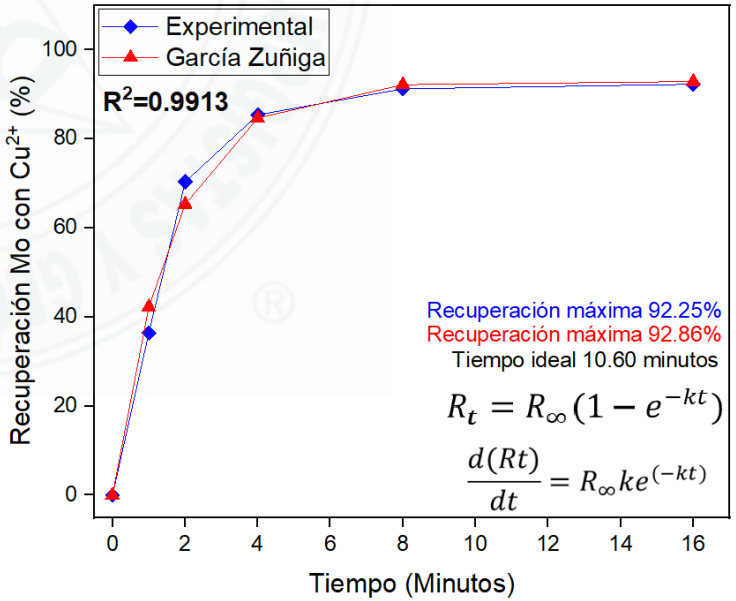




Cobre con iones Cu^{2+}

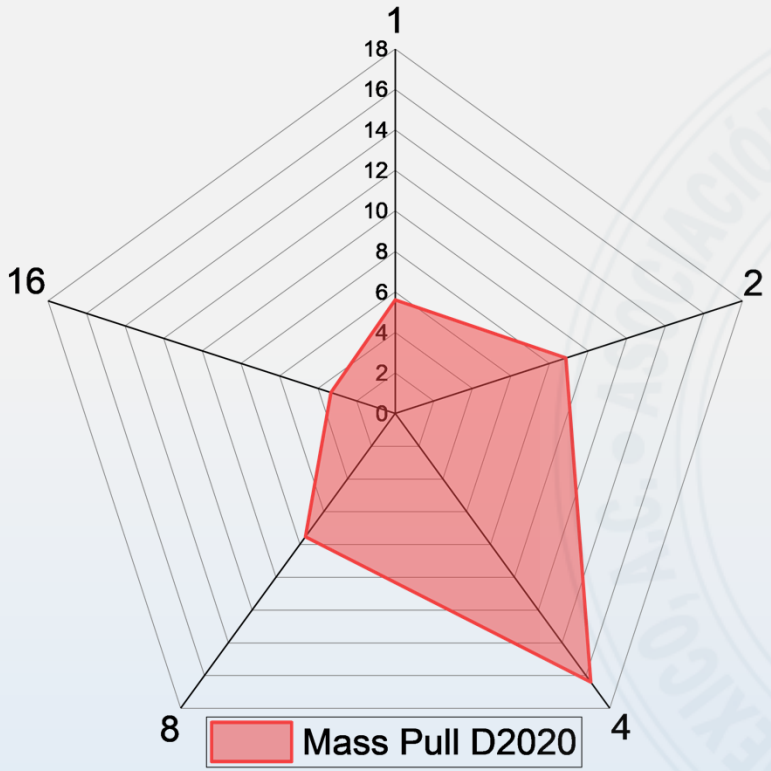
Molibdeno sin iones Cu^{2+}

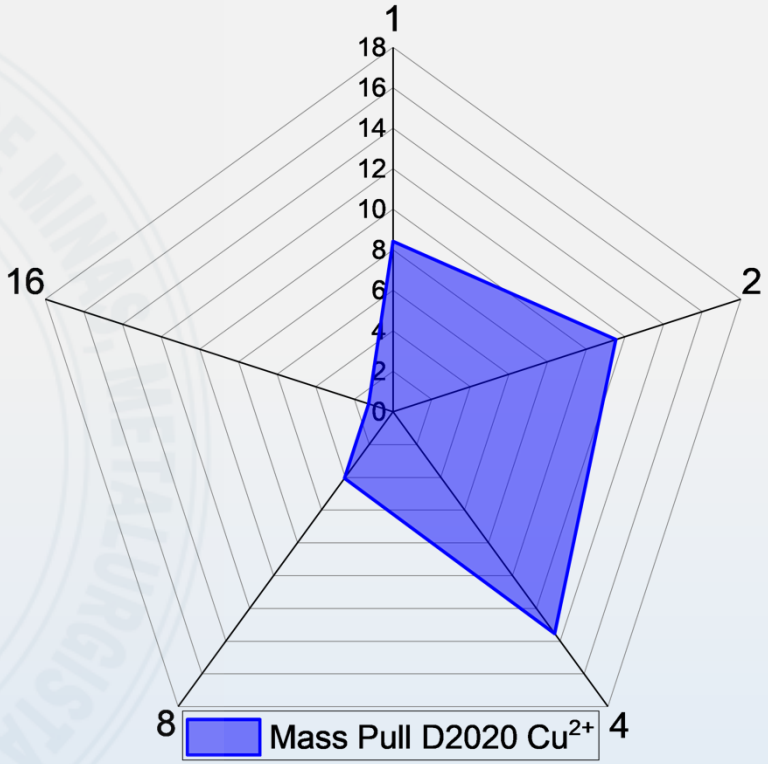




Molibdeno con iones Cu^{2+}

Empuje de masa de Cinéticas





Exhibe un marcado pico de 16.41% a los 4 minutos, precedido por valores ascendentes (5.60% a 1 min; 8.85% a 2 min) y seguido de un descenso abrupto (7.53% a 8 min; 3.33% a 16 min).

Levante mas elevado a 1 minuo 8.41%, alcanzando un pico máximo reducido a 13.54% a los 4 minutos. Posteriormente decae drásticamente a 4.06% a 8 minutos y 1.26% a 16 min

Conclusión

- El comportamiento en flotaciones primarias muestra mejores rendimientos en condiciones alcalinas.
- Los iones cúpricos benefician la separación entre la molibdenita y sulfuros de cobre.
- La sobredosificación afecta la estequiometria de quelación al saturar los sitios activos superficiales de la calcopirita y oxidar ligeramente la molibdenita.
- Un control preciso de concentración de iones Cu^{2+} beneficia la selectividad en circuitos Cu-Mo en presencia de tioles

Bibliografía

- G. Yi, E. Macha, J. Van Dyke, et al., Recent progress on research of molybdenite flotation: A review, Advances in Colloid and Interface Science (2021), https://doi.org/10.1016/j.cis.2021.102466
- Wenqing Qin, Jiajia Wu, Fen Jiao, Jinming Zeng, Mechanism study on flotation separation of molybdenite from chalcocite using thioglycollic acid as depressant, International Journal of Mining Science and Technology, Volume 27, Issue 6, 2017, Pages 1043-1049, ISSN 2095-2686, https://doi.org/10.1016/j.ijmst.2017.06.011.
- Zhang, C., He, T., Chen, W., Bu, X., Wang, S., & Tian, X. (2020). The Auxiliary Effect of Copper Ions on the Depressant Effect of Sodium Thioglycolate in Chalcopyrite Flotation. *Minerals*, *10*(2), 157. https://doi.org/10.3390/min10020157.
- Jiang, F.; He, S.; Qi, J.; Luo, Y.; Tang, H. Unraveling the Impact of Copper Ions on Mineral Surfaces During Chalcopyrite–Molybdenite Flotation Separation Using Sodium Thioglycolate. Appl. Sci. 2025, 15, 7293. https://doi.org/10.3390/app15137293.
- Wei, B.; Mao, Y.; Wang, L.; Shen, P.; Wang, H.; Liu, D. Sources, Performance and Mechanisms of Metal Ions in the Flotation Process of Copper, Lead, and Zinc Ores: A Review. Minerals 2024, 14, 1105. https://doi.org/10.3390/min14111105

Universidad Autónoma de Coahuila
Mathiesen México

Por su atención
¡GRACIAS!

Hazel René Gallegos Moreno
hgallegos@grupomathiesen.com

XXXVI CONVENCIÓN INTERNACIONAL DE MINERÍA ACAPULCO 2025
LA MINERÍA UNIDA POR MÉXICO