Evaluation of Molybdenum Concentrates

Kagan Benzeşik, Seref Sonmez and Onuralp Yücel

Abstract The aim of this study is processing of domestic molybdenum concentrate to produce technical grade molybdenum trioxide may be the starting material for the production of various molybdenum products. In order to determine the optimum parameters for the total oxidizing roasting process of molybdenite concentrate to produce MoO_3 and purify the MoO_3 product by removing the copper content; first, MoS_2 was roasted by controlling reaction temperature and duration in a chamber type furnace. The highest Mo concentration rate was obtained as 56.6 wt% of Mo at 650 °C for the roasting duration of 45 min. Secondly, roasted product was leached with H_2SO_4 to remove copper. Leaching conditions were optimized by investigating the effects of different H_2SO_4 concentrations and S/L ratios. The minimum copper content was obtained as 0.13 wt% at leach residue. The raw materials and the products were characterized by using AAS (atomic absorption spectrometry) and XRD (X-Ray Diffraction) techniques.

Keywords Molybdenite · Roasting · Technical-grade molybdenum trioxide · Leaching

Introduction

Generally molybdenum metal is produced from its high grade sulphide concentrate through oxidizing roasting of molybdenite (MoS_2) in order to obtain molybdenum trioxide (MoO_3). Then purification of MoO_3 and hydrogen reduction of MoO_3 follows.

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J.-Y. Hwang et al. (eds.), *8th International Symposium on High-Temperature Metallurgical Processing*, The Minerals, Metals & Materials Series,
DOI 10.1007/978-3-319-51340-9_43

Molybdenum is widely used for the production of ferromolybdenum, which is required for the production of alloyed steel. Almost 80% of Mo, produced from molybdenum trioxide, is used for steel making in industries.

Usually, concentrates are roasted to obtain low copper and lead levels to produce a calcine that is essentially MoO_3 which contains low sulphur. Such calcines can be used directly in steel making, because liquid iron will reduce MoO_3 to metal in high yield.

Technical-grade MoO_3 is produced by roasting MoS_2 in air atmosphere in a multiple-hearth furnace. The roasted MoO_3 product usually has <0.1% sulphur content. Technical-grade MoO_3 typically contains 85–90 wt% MoO_3, the balance is silica with some Fe_2O_3 and Al_2O_3.

In some cases, additional hydrometallurgical processing is needed to produce technical-grade MoO_3. In steel making, using molybdenum trioxide with high copper content has some harmful effects on the mechanical properties of the alloyed steel produced. Therefore, the up-gradation of molybdenum trioxide is required in steel industry. The up-graded molybdenum trioxide must have less than 0.5 wt% Cu content for ferromolybdenum production [1–4].

Experimental Procedure

The raw material which was used in total oxidizing roasting experiments, is local molybdenite concentrate which has 0.40 wt% Cu and 0.05 wt% Mo content. The XRD pattern of MoS_2 concentrate is shown in Fig. 1.

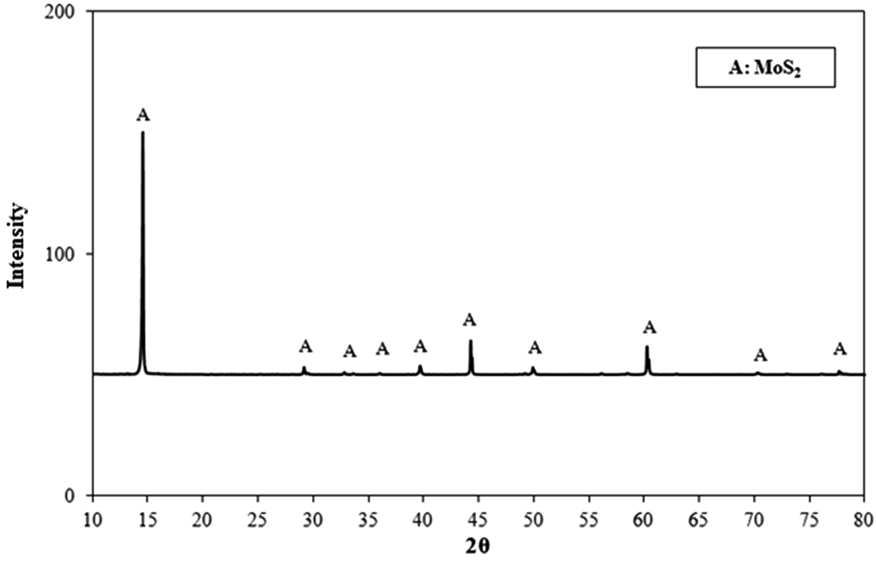

Fig. 1 XRD pattern of MoS_2 concentrate

Table 1 Chemical analysis of MoS_2 concentrate

Mo	52.03
S	39.19
C	0.05
Fe	2.94
Cu	2.56
Pb	0.08
Si	1.30
Al	0.45
Ca	0.60
Mg	0.17

MoS_2 concentrate was analyzed by using chemical analysis and AAS. Chemical analysis of MoS_2 concentrate is given in Table 1.

Present study was conducted in two main stages: First, MoS_2 was roasted by controlling parameters such as reaction temperature and duration in a chamber type furnace. To make a homogeneous roasting, alumina boats which have large surface area, were used. The samples were put in the alumina boats as thin layers. Samples were roasted at 600, 625, 650 °C with 15, 30, 45, 60, 90 and 120 min.

In the second experimental sets, roasted products were leached by H_2SO_4 to remove copper. Leaching conditions were optimized by investigating the effects of different H_2SO_4 concentrations and S/L ratio. Leaching experiments were done with Merck quality 95–98% H_2SO_4 with the duration of 15 min, at room temperature and 400 rpm mixing rate. All the samples were 10 g. In order to investigate the effects of different H_2SO_4 concentrations and S/L ratios, 10 g of samples were leached with 0.2, 0.4, 0.6 M acid concentrations with 1/5, 1/2 and 1/1 solid-liquid ratios.

Results and Discussion

In the first experimental set, effect of roasting temperature and duration on molybdenum trioxide recovery were investigated. In Fig. 2, the change of sulphur content at the concentrate depending on the roasting temperature and duration, is given.

As it is seen from Fig. 2, the sulphur content of the concentrates decreases rapidly till 40 min of roasting. It can be said that roasting at 650 °C with the duration of 45 min has given the closest results to the standard technical-grade MoO_3. As the roasting temperature and duration decrease, the sulphur amount increases.

The chemical analysis of the samples which were roasted at different temperatures and durations, is given in Table 2.

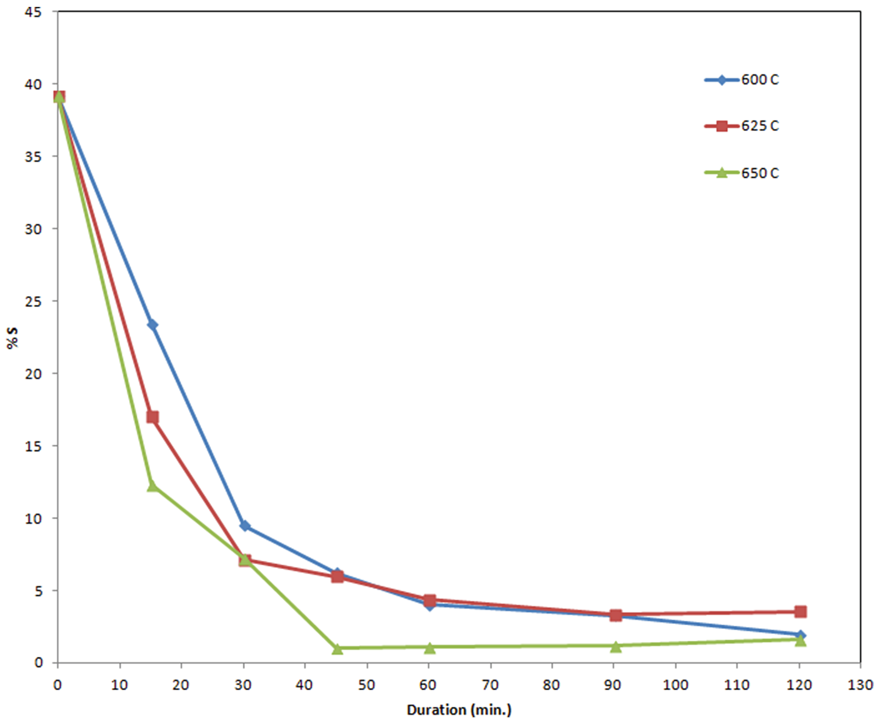

Fig. 2 The change of sulphur content at the concentrate

Table 2 The chemical analysis of the roasted samples

Duration (min)	Temperature (°C)	Concentration (%)		
		Cu	Fe	Mo
15	600	2.84	3.60	46.51
45		3.02	3.65	50.82
60		2.89	3.96	48.11
15	625	2.81	3.41	50.19
45		2.96	3.51	48.79
60		2.97	3.81	49.36
15	650	2.31	3.28	58.10
45		2.62	3.49	56.58
60		2.77	3.72	52.38

The optimum Mo concentration rate was obtained as 56.58 wt% at 650 °C for the roasting duration of 45 min.

In the second experimental sets, roasted product was leached by H_2SO_4 to remove copper. Leaching conditions were optimized by investigating the effects of different H_2SO_4 concentrations and S/L ratio.

The metal concentrations in H_2SO_4 solutions are given in Table 3.

Table 3 The metal concentrations in H_2SO_4 solutions

Molarity	S/L ratio	Metal concentrations in H_2SO_4 solution (ppm)		
		Cu	Fe	Mo
0.2	1/5	566.75	125.15	2200.00
	1/2	483.25	106.70	1650.00
	1/1	1123.00	231.85	3770.00
0.4	1/5	789.50	171.85	1274.00
	1/2	794.50	198.50	1450.00
	1/1	717.50	140.95	1116.00
0.6	1/5	762.25	190.50	1787.50
	1/2	903.00	224.25	2090.00
	1/1	866.70	212.70	1650.00

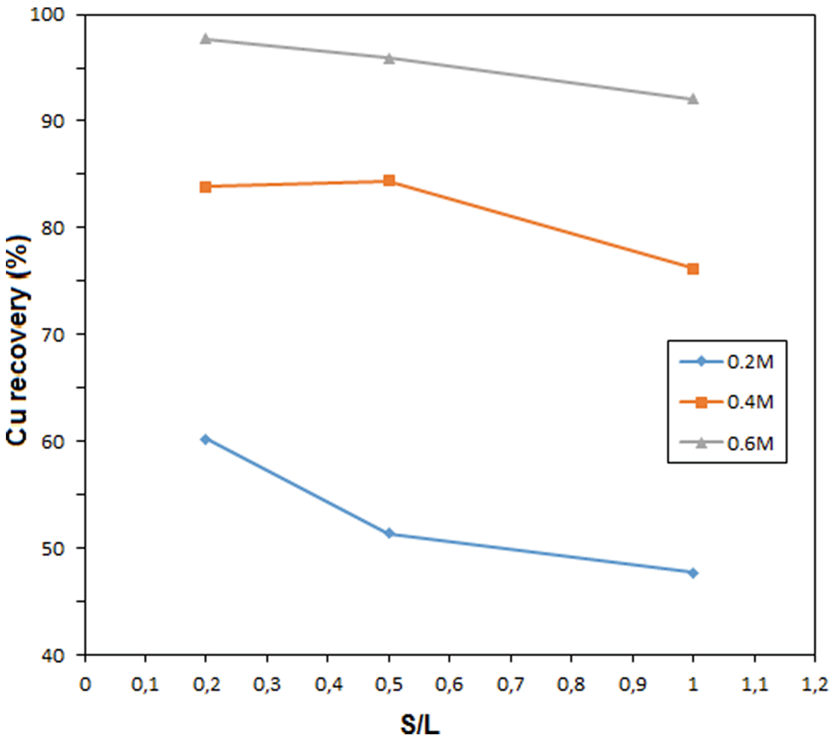

Fig. 3 The effects of different H_2SO_4 concentrations and S/L ratios on Cu recovery from the solution

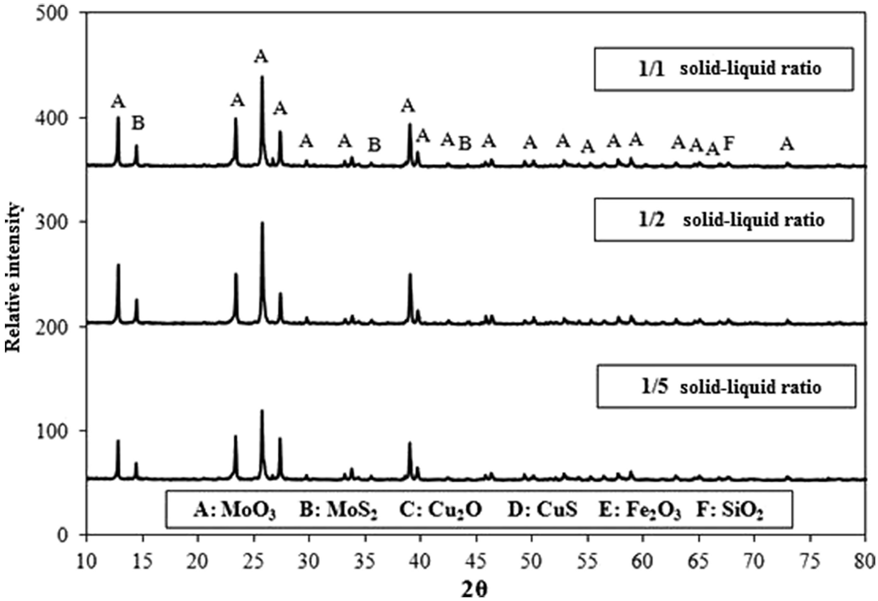

Fig. 4 XRD patterns of leached samples with 0.6 M H_2SO_4 solution

The concentration values were put in Formula (1) in order to calculate the metal recovery from H_2SO_4 solutions.

$$\text{Metal recovery}\,(\%) = \frac{\text{concentration}\,(\text{ppm}) \times \text{stock}\,(\text{ml}) \times 100}{10^6 \times \text{metal mass in the samples}\,(\text{g}) \times \text{metal ratio}} \quad (1)$$

In Fig. 3, the effects of different H_2SO_4 concentrations and S/L ratios on Cu recovery from the solution are given.

As it is seen from Fig. 4, almost 96% of Cu was removed from calcine by using 0.6 M H_2SO_4 solution at 1/5 solid-liquid ratio [5, 6].

Figure 4 presents the XRD patterns of leached samples with 0.6 M H_2SO_4 solution.

Figure 4 shows that, the main phases of leaching residue are MoO_3. There are not seen any copper compounds rather the roasted samples. Because the majority of the copper was solution treated.

Conclusions

Based on the results of present study of roasting molybdenite concentrate at different temperatures and durations, leaching of roasted samples with different H_2SO_4 concentrations at different solid-liquid ratios, following conclusions can be given.

(1) Optimum Mo recovery was determined as 56.58% Mo and 1.05% S with the roasting temperature of 650 °C and duration of 45 min.
(2) Leaching with 0.6 M H_2SO_4 solution at 1/5 solid-liquid ratio ended up with 95.92% Cu recovery from the H_2SO_4 solution. These parameters gave the best results as 0.13% Cu content in the leaching residue.

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