

Case study of producing acidic oxide: sulfur dioxide

[Science](#), [Chemistry](#)



CASE STUDY 1: Xstrata Produced Acidic Oxide — SULFUR DIOXIDE Industrial Process — Sulfur Dioxide is an acidic oxide produced domestically and industrially in many ways. Xstrata, particularly Mount Isa Mines LTD, produces sulfur dioxide as a by-product from the extraction of copper from ores. Copper ore mined in Australia is predominantly chalcopyrite (CuFeS_2), a sulfide ore of copper. The extraction of copper begins with crushing the ore and subjecting the crushed ore to froth floatation. In this the concentrated copper ores float to the top of a bath and are collected, and the gangue (rock and other unwanted silicate materials) are left behind. The concentrated ore is now predominantly CuFeS_2 and is roasted in air with the following effects -

$$2\text{CuFeS}_2(\text{s}) + 3\text{O}_2 \rightarrow 2\text{CuS}(\text{s}) + 2\text{FeO}(\text{s}) + 2\text{SO}_2(\text{g})$$

This is the first time sulfur dioxide is produced in the extraction process. The Copper (II) Sulfide (CuS) is then heated at 1100°C , with crushed limestone and sand, and is converted to Copper (I) Sulfide (Cu_2S). The Copper (I) Sulfide is then roasted in air and some is oxidised to Cu_2O . These two then react to form Copper metal, Both reactions described below —

$$2\text{Cu}_2\text{S}(\text{s}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{Cu}_2\text{O} + 2\text{SO}_2$$

$$2\text{Cu}_2\text{O}(\text{s}) + \text{Cu}_2\text{S}(\text{s}) \rightarrow 6\text{Cu}(\text{l}) + \text{SO}_2$$

This is the end of the processes that produce the oxide. The Copper goes through more refining electrolytically. Evidently, Sulfur Dioxide is a major by-product Impacts — Sulfur Dioxide (SO_2) has many detrimental effects to society and environment. Firstly, exposure to high levels (10-50 parts per million (PPM)) of SO_2 can cause irritation to the eyes, throat, nose and airways. This causing coughing, wheezing and serious breathing problems to asthma sufferers. A more common effect on society and the environment is it dissolving in water and oxygen in the atmosphere to form acid rain — $\text{SO}_2(\text{g})$

$\text{S} + \text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{SO}_3$ $2\text{H}_2\text{SO}_3 + \text{O}_2 \rightarrow 2\text{H}_2\text{SO}_4$ Sulfuric Acid (H_2SO_4) is a result of the reaction in the is the main component of acid rain which has many negative effects. It accelerates the decay of man-made structures such as buildings and statues, making them unattractive and in need of repair, which society has to pay for, through the government or businesses. For example concrete, limestone and marble (both of which have are made of calcium carbonate) and metal structures — $\text{Ca}(\text{OH})_2 + \text{H}_2\text{SO}_4 \rightarrow \text{CaSO}_4 + 2\text{H}_2\text{O}$ $\text{CaCO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{CaSO}_4(\text{aq}) + \text{H}_2\text{O} + \text{CO}_2$ $\text{Fe}(\text{s}) + \text{H}_2\text{SO}_4 \rightarrow \text{FeSO}_4(\text{aq}) + \text{H}_2$ As above, acid rain turns an ingredient of concrete into a much weaker salt; and limestone/marble and metal into an aqueous solution, which will get washed away in water. Over the years can lead to little structural integrity and the accelerated erosion of statues, pillars and other monuments. It also effects the environment through altering forests, lakes and and aquatic habitats. Plants' leaves and stems are harmed as well as the soil being contaminated, leading to insufficient nutrients to the roots of plants which may lead to the plant not being able to photosynthesise or reproduce. This has many roll on effects being lose of habitat of animals in forest and change in the hydro-environment. With the acidity of water increasing comes with disturbances with chemical equilibriums of fish and eggs. This causes disturbances with their life and waste cycle — which is detrimental to their species.

Company Steps to Minimise Release — Mount Isa Mine LTD, has taken many steps to try and minimise the release of this Sulfur Dioxide. The most significant step being the introduction of an acid plant in 2000. The acid plant collects the majority of the Sulfur Dioxide emissions from the smelter, turns them to sulfuric acid and transport this to

other plants for use in the production of fertilisers — (CATALYST) $2\text{SO}_2 + \text{O}_2 \rightarrow 3\text{SO}_3$ $\text{SO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{S}_2\text{O}_7$ $\text{H}_2\text{S}_2\text{O}_7 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$ The plant has decreased the Sulfur Dioxide emissions by 76% since its establishment. In conjunction with the plant, the company installed a wet scrubber which reduces the Sulfur Dioxide emissions by using chemical reactions to turn some of the emissions to more benign substances — $\text{SO}_2 + \text{CaCO}_3 + \text{H}_2\text{O} + \text{O}_2 \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O} + \text{CO}_2$ The establishment of the Xstrata Air Quality Control Centre (AQCC) has provided the mine with a state-of-the-art monitoring system which monitors air quality in the immediate area. It also has the ability to shut down operations when Sulfur Dioxide concentration in the air is too high or if westerly winds are too strong. This is to lessen emissions to the surrounding Mount Isa residents. For example in 2010 the AQCC limited smelter operations to 889 hours due, compared to 931 hours in 2009.

CASE STUDY 2: Bluescope Steel Produced Acidic Oxide — CARBON DIOXIDE Industrial Process — The industrial process that produces Carbon Dioxide occurs in the extraction of iron from its ore. The most common iron ore, Hematite (Fe_2O_3), is widely used for the extraction of iron. The process begins with hot air burning/combusting coke, limestone and hematite. Coke is used to create heat energy and other by-products, as it is a strongly exothermic reaction, since the temperature in the furnace must get up to around 1800°C . The important by-product produced in the combustion of coke is Carbon dioxide, which at high heats reacts with carbon to make carbon monoxide — $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$ $\text{C} + \text{CO}_2 \rightarrow 2\text{CO}$ This production of Carbon Dioxide to Carbon Monoxide is integral to the process, as Carbon Monoxide is used in the main reaction to reduce the hematite — $\text{Fe}_2\text{O}_3(\text{s})$

$+ 3\text{CO}(\text{g}) \rightarrow 2\text{Fe}(\text{l}) + 3\text{CO}_2(\text{g})$ The reaction creates molten iron and Carbon Dioxide. But rocky material, present in the iron ore, can clog the taps at the bottom of the furnace (see diagram). $\text{CaCO}_3 + \text{Heat} \rightarrow \text{CaO} + \text{CO}_2$ This is another reaction in the process that produces Carbon Dioxide. Limestone (calcium carbonate) is decomposed in heat and the Calcium Oxide reacts with the rocky material such as $\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3$ Which are liquids, at the heats in the blast furnace, an is 'slag' which does not clog the furnace. It is evident that CO_2 is a major emission. Impacts — Carbon Dioxide is well known for it's harmful effects to the environment. The most significant of these is the enhanced greenhouse effect. With a substantial increase in the emissions of CO_2 since the use of coal and gas power for cars and electricity the amount of CO_2 in the atmosphere has also increased. This increase has lead to the enhanced greenhouse effect. Where heat energy from the sun, rather than escaping the Earth's atmosphere, is absorbed and reflected back to the surface. This has seen a notable increase of average temperature of land and water. This has been melting the polar ice caps, destroying the habitat of a multitude of polar species. Temperature fluctuations negatively effect animal breeding cycles, such as whales, who depend on temperature of water to breed. The majority of Carbon Dioxide is dissolved in ocean — $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$ creating Carbonic Acid. This is leading to the pH of oceans and waterways to rise, having ill effects similar to the acidification of water ways due to Acid Rain (Case Study 1). Society is effected through more extreme weather caused by the enhanced greenhouse effect ie longer and hotter droughts, more severe cyclones and floods. The melting of the ice-caps effect coastal societies because they will have to find settlements

more inland due to the rising sea levels. Higher levels of CO₂ in the atmosphere can lead to a higher concentration of CO₂ in human blood stream. This disturbs chemical equilibrium in the body and is linked to kidney disease and comas.

Company Steps to Minimise Release — The company, BlueScope Steel, has invested almost \$500 million on environmental initiatives. Port Kembla Steelworks has spent \$18 million on upgraded sinter machines that reduce the amount of coke need for the sintering process. The sintering process being getting the small particle of iron that were too small to go through processing and putting them through 1100-1300oC heat they will coalesce and form larger particles which improves resource efficiency. The upgrade involve using natural gas rather than coke to generate the heat in the machine because natural gas has a higher heat of combustion than coke and therefore needs less to fuel the same get the same heat. This means less CO₂ emissions and less fuel needed to burn. Port Kembla has also reduced it's steel production from 5. 3 million tonnes per annum to 2. 6 million tonnes per annum to follow decreasing domestic steel demand, not waste resources and put unnecessary CO₂ in the atmosphere. The decrease of steel production will correlate with an decrease in CO₂ emission and environmental footprint as a whole. (<http://www.chemguide.co.uk/inorganic/extraction/blastfurnace.gif>)