The ultimate fate of most of the SO₂ in the atmosphere is conversion to sulfate salts, which are removed by sedimentation or by washout with precipitation. The conversion to sulfate is by either of two routes: catalytic oxidation or photochemical oxidation. The first process is most effective if water droplets containing Fe³⁺, Mn²⁺, or NH₃ are present:

\[ 2\text{SO}_2 + 2\text{H}_2\text{O} + \text{O}_2 \xrightarrow{\text{catalyst}} 2\text{H}_2\text{SO}_4 \]  

(6-15)

At low relative humidities, the primary conversion process is photochemical oxidation. The first step is photoexcitation of the SO₂:\n
\[ \text{SO}_2 + \text{hv} \rightarrow \text{SO}_2^* \]  

(6-16)

The excited molecule then readily reacts with O₂ to form SO₃:

\[ \text{SO}_2^* + \text{O}_2 \rightarrow \text{SO}_3 + \text{O} \]  

(6-17)

The trioxide is very hygroscopic and consequently is rapidly converted to sulfuric acid:

\[ \text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 \]  

(6-18)

This reaction in large part accounts for acid rain (that is, precipitation with a pH value less than 5.6) found in industrialized areas. Normal precipitation has a pH of 5.6 due to the carbonate buffer system.

**Particulates**

Sea salt, soil dust, volcanic particles, and smoke from forest fires account for 1.404 Pg of particulate emissions each year. Anthropogenic emissions from fossil fuel burning and industrial processes account for emissions of 92 Tg per year. Secondary sources of particulates include the conversion of H₂S, SO₂, NOₓ, NH₃, and hydrocarbons. H₂S and SO₂ are converted to sulfates. NOₓ and NH₃ are converted to nitrates. The hydrocarbons react to form products that condense to form particles at atmospheric temperatures. Natural sources of secondary pollutants yield about 1.099 Pg annually. Anthropogenic sources yield about 0.204 Pg annually.

Dust particles that are entrained (picked up) by the wind and carried over long distances tend to sort themselves out to the sizes between 0.5 and 50 µm in diameter. Sea salt nuclei have sizes between 0.05 and 0.5 µm. Particles formed as a result of photochemical reactions tend to have very small diameters (< 0.4 µm). Smoke and fly ash particles cover a wide range of sizes from 0.05 to 200 µm or more.

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24Photoexcitation is the displacement of an electron from one shell to another, thereby storing energy in the molecule. Photoexcitation is represented in reactions by an asterisk.
