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SULPHUR PRODUCTION

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ABSTRACT OF THE DISCLOSURE

An improved process for the production and recovery of elemental sulphur from the reaction of hydrogen sulfide and sulphur dioxide. The improvement comprising performing the process in liquid sulphur in the presence of a basic nitrogen compound catalyst having an equilibrium constant (K_B value) greater than 10^{-10}.

This invention relates to the production of elemental sulphur and more particularly relates to methods which enhance the conversion of hydrogen sulfide and sulphur dioxide into elemental sulphur and water in accordance with the following equation:

$$2H_2S+SO_2 \rightarrow 3S+2H_2O$$

Industrially, the most significant utilization of the reaction of hydrogen sulfide and sulphur dioxide is the recovery of sulphur from gas streams containing hydrogen sulfide or sulphur dioxide. For example, in various modifications of the Claus Process, hydrogen sulfide and sulphur dioxide are reacted on a catalyst to yield elemental sulphur and water vapor.

The reaction between hydrogen sulfide and sulphur dioxide, although thermodynamically favorable, is very slow in the absence of catalysts at ordinary temperatures. However, several methods of catalyzing this reaction are known. The most widely recognized methods known to those skilled in the art are the Townsend Process and modifications of the Claus Process. In the Townsend Process the catalytic reaction of hydrogen sulfide and sulphur dioxide is carried out at low temperatures in a hygroscopic organic liquid, such as diethylene glycol, containing less than ten percent by weight of water. However, the Townsend Process has the distinct disadvantage that the produced elemental sulphur forms a slurry with the organic reaction medium, which necessitates a subsequent separation step in the process. Another method of catalytically reacting hydrogen sulfide with sulphur dioxide is practiced in various modifications of the Claus Process. This method consists of passing the gas stream through a catalytic converter. One disadvantage of this method is that the converters have to be operated at relatively high temperatures, specifically, at temperatures above the dew point of sulphur, resulting in the necessity of employing condensers to liquefy the sulphur that is produced in the vapor phase. Moreover, the presence of gases other than the reactants in the gas stream frequently has a detrimental effect on the solid catalysts used in modifications of the Claus Process. It is partially for this reason that gas streams fed to Claus converters are previously treated to remove the hydrocarbons and to concentrate the sulphur gases. The Claus Process has the further disadvantage of being relatively expensive because of the cost involved in compressing the gases fed to the converter and because of the limited lifetime of the catalyst.

Thus, it is desirable to obtain a more efficient and economical method by which hydrogen sulfide and sulphur dioxide could be reacted together to yield elemental sulphur.

It is an object of the present invention to provide a method which enhances the recovery of elemental sul-

phur from the reaction of hydrogen sulfide and sulphur dioxide.

It is another object of this invention to provide a method of sulphur production from the reaction of hydrogen sulfide and sulphur dioxide, in which the elemental sulphur is produced in the liquid state.

It is a further object of the present invention to provide a method for decreasing the level of hydrogen sulfide and/or sulphur dioxide contamination in liquid elemental sulphur.

Other objects of the invention wil be apparent to those skilled in the art from reading the present description, taken in conjunction with the appended drawings, in which FIGURES 1, 2, 3 and 4 represent schematic flow diagrams of methods for conducting the present invention.

The objects of this invention may be achieved by adding at least about one part per million of certain catalysts, preferably liquid or solid, to liquid or molten sulphur and then contacting a gas stream containing hydrogen sulfide and sulphur dioxide with the molten sulphur. Surprisingly, it has been discovered that the reaction of hydrogen sulfide with sulphur dioxide in liquid sulphur is very fast if a basic nitrogen compound in accordance with the present invention is present in the liquid sulphur, while in the absence of such a basic nitrogen compound this reaction is very slow.

The catalytic compounds or additives to be added to the liquid sulphur reaction medium which have been found to be effective in the practice of this invention are the basic nitrogen compounds which are soluble in liquid sulphur to the extent of at least about one part per million and which have a K_B value greater than about 10^{-10}, including the class of compounds consisting of:

(A) Ammonia and its inorganic derivatives having a K_B value greater than 10^{-10}. Such compounds include hydrazine, hydroxylamine, etc.

(B) Primary, secondary and tertiary, alkyl, aryl and cyclic amines having a K_B value greater than 10^{-10}. Such amines include: N-butylamine, tetradecyldimethylamine, aniline, cyclohexylamine, N,N-diethylcyclohexylamine, N-methylpyrrolidine, pyridine, tetraethylenepentamine, ethylenediamine, piperidine, indole, 1-(2-aminoethyl)-2-(n-heptadecenyl-2)-imidazoline, n-amylamine, N,N-dimethyloctadecylamine, N,N-dimethyltetradecylamine, N,N-dimethylhexadecylamine, N,N-dimethyloctadecylamine, N,N-dimethylamylamine, α-methylamylamine, propylamine, β,β-dimethylpropylamine, sec-butylamine, isobutylamine, hexylamine, N,N-dimethylhexylamine, n-heptylamine, N,N-dimethylheptylamine, octylamine, tertiary butylamine, α,α-dimethylpropylamine, α,α-dimethylbutylamine, and guanidine. This list of basic nitrogen compounds should not be considered a limitation on the scope of the present invention because there exist many other nitrogen compounds too numerous to mention which may be employed in the present invention.

(C) Quaternary basic nitrogen compounds which decompose between 20° and 160° C. to yield ammonia or its inorganic derivatives having a K_B value greater than 10^{-10}. Such compounds include ammonium carbonate, ammonium bicarbonate, etc.

(D) Quaternary basic nitrogen compounds which on heating to temperatures between 20 and 160° C. decompose to yield an organic amine having a K_B value greater than 10^{-10}. Such compounds include tetramethylammonium hydroxide, tetraethylammonium hydroxide, etc.

As used throughout this disclosure the term K_B identifies the equilibrium constant defined by the equation:

$$K_B=\frac{[OH^-]\times[BH^+]}{[B]}$$

which applies to the reaction:

$$B+H_2O \rightleftharpoons BH^+ + OH^-$$