SELEC' VE REMOVAL OF HYDROGEN SULFIDE OVER ZINC TITANATE AND ALUMINA

This invention relates to an improved process for selectively removing hydrogen sulfide from fluid streams.

The removal of sulfur from fluid streams can be desirable or necessary for a variety of reasons. If the fluid stream is to be released as a waste stream, removal of sulfur from the fluid stream can be necessary to meet the sulfur emission requirements set by various air pollution control authorities. Such requirements are generally in the range of about 10 ppm to 500 ppm of sulfur in the fluid stream. If the fluid stream is to be burned as a fuel, removal of sulfur from the fluid stream can be necessary to prevent environmental pollution. If the fluid stream is to be processed, removal of the sulfur is often necessary to prevent the poisoning of sulfur sensitive catalysts or to satisfy other process requirements.

A variety of methods are available to remove sulfur from a fluid stream if the sulfur is present as hydrogen sulfide. These methods include using alkaline reagents that unselectively absorb all acid gases. Other methods include the use of selective solid absorbants such as zinc oxide and barg iron ore. However, in general, these solid absorbants are not regenerable to their original form and must be discarded when they have become completely sulfided.

US Patent 4,371,728 discloses a composition comprising zinc, titanium and at least one metal promoter which is an effective absorbing composition for hydrogen sulfide and which possesses the property of being regenerable to the original absorbing composition state in the presence of oxygen when fully sulfided. Although the composition disclosed by US Patent 4,371,728 is an effective absorbing composition for hydrogen sulfide, it has now been found that the addition of alumina to the composition provides a more effective sulfide-absorbing composition.

Thus, in accordance with one aspect of the present invention, there is provided a sulfide-absorbing composition comprising zinc titanate and alumina, wherein the alumina is present in an amount of from about 10 weight-% to about 55 weight-%, said composition being promoted with one or both of tungsten and molybdenum and with at least one metal from Group VIII of the Periodic Table, the promoters, i.e. the tungsten and/or

molybdenum and the Group VIII metal, being present in the absorbing composition in the oxide form. In a second aspect, such compositions are utilized to selectively remove hydrogen sulfide from a fluid stream containing it. The absorbing composition of this invention can be formed by initially combining the zinc titanate and alumina and thereafter adding the metal promoters in accordance with any of the methods known in the art, and calcining to convert the promoters into the oxide form if not already added as such. Once the absorbing composition has been prepared, fluid streams which contain hydrogen sulfide are contacted with the absorbing composition under suitable absorbing conditions to substantially reduce the concentration of hydrogen sulfide in the fluid stream.

It is believed that the hydrogen sulfide is being absorbed by the absorbing composition and thus the terms "absorption process" and "absorbing composition" are utilized for the sake of convenience. However, the exact chemical phenomenon occurring is not the inventive feature of the process of the present invention and the use of the term "absorb" in any form is not intended to limit the present invention.

The selective absorption process is preferably carried out in cycles comprising an absorption period and a regeneration period for the absorbing composition. The absorption period comprises contacting a fluid stream which contains hydrogen sulfide with the absorbing composition thereby to selectively remove hydrogen sulfide from the fluid stream. The absorbing composition becomes sulfided during the absorption period. When the absorbing composition becomes sulfided to the point that regeneration is desirable, preferably when it is nearly completely sulfided, an oxygen-containing gas is passed in contact with the absorbing composition to regenerate the absorbing composition and convert the absorbed sulfur to an oxide.

The chemical changes that are believed to occur in the abosrbing composition during this cyclic process where sulfur is present are summarized in the following equations:

(I) $Zn_2TiO_4 + 2H_2S \longrightarrow 2ZnS + TiO_2 + 2H_2O$

(II) $ZnS + \text{Oxygen} \longrightarrow ZnO + SO_x$

(III) $2ZnO + TiO_2 \longrightarrow Zn_2TiO_4$

The absorbing composition of the present invention may be utilized to remove hydrogen sulfide from any suitable fluid stream. The hydrogen

sulfide may be produced by the hydrodesulfurization of organic sulfur compounds or may be originally present in the fluid stream as hydrogen sulfide. Suitable fluid streams include light hydrocarbons such as methane, ethane and natural gas; petroleum products and products from extraction and/or liquefaction of coal and lignite; a Claus tail gas; products from tar sands and shale oil; coal derived synthesis gas; gases such as hydrogen and nitrogen; fluid oxides of carbon; steam and the inert gases such as helium and argon. Gases that adversely affect the removal of hydrogen sulfide and which should be absent from the fluid streams being processed are oxidizing agents such as molecular oxygen, the halogens, the oxides of nitrogen, and the like.

The absorbing composition of the present invention may be utilized to remove hydrogen sulfide from olefins such as ethylene. This process, however, should be carried out in the absence of free hydrogen to avoid hydrogenation. Olefin streams should not be hydrodesulfurized as this may result in undesirable hydrogenation of at least a portion of the olefins to paraffins.

The absorbing composition of the present invention may be utilized to reduce the concentration of hydrogen sulfide in a fluid stream to any suitable amount. The concentration of hydrogen sulfide in a fluid stream will generally be reduced to below about 100 ppm and will more preferably be reduced to below about 10 ppm.

In accordance with the preferred method of preparation, the absorbing composition is prepared by first preparing zinc titanate which is then reduced to a small size. The resulting material is mixed with a hydrosol of a suitable acidic material comprising alumina. A suitable base is then added to the mixture to form a hydrogel. The resulting hydrogel is dried slowly and calcined to form a hydrogel derived absorbing composition of zinc titanate and alumina.

The promoters are then added to the hydrogel derived absorbing composition of zinc titanate and alumina. The promoters may be added separately or in the form of a metal tungstate or metal molybdate.

The zinc titanate portion of the absorbing composition may be prepared by intimately mixing suitable portions of zinc oxide and titanium dioxide, preferably in a liquid such as water, and calcining the mixture in the presence of free oxygen at a temperature in the range of about 650°C to about 1050°C, preferably in the range of about 675°C to about 975°C, to

form zinc titanate. A calcining temperature in the range of about 800°C to about 850°C is most preferred because the surface area of the zinc titanate is maximized in this temperature range, thus producing a more active zinc titanate. The titanium dioxide used in preparing the zinc titanate preferably has extremely fine particle size to promote intimate mixing of the zinc oxide and titanium dioxide. This produces a rapid reaction of the zinc oxide and titanium dioxide which results in a more active zinc titanate. Preferably the titanium dioxide has an average particle size of less than 100 millimicrons and more preferably less than 30 millimicrons. Flame hydrolyzed titanium dioxide has extremely small particle size and is particularly preferred in preparing the zinc titanate. The atomic ratio of zinc to titanium can be any suitable ratio. The atomic ratio of zinc to titanium will generally lie in the range of from about 1:1 to about 3:1 and will preferably lie in the range of from about 1.8:1 to about 2.2:1 because the activity of the zinc titanate is greatest for atomic ratios of zinc to titanium in this range. The term "zinc titanate" is used regardless of the atomic ratio of zinc to titanium.

The zinc titanate portion of the absorbing composition may also be prepared by coprecipitation from aqueous solutions of a zinc compound and a titanium compound. The aqueous solutions are mixed together and the hydroxides are precipitated by the addition of ammonium hydroxide. The precipitate is then washed, dried and calcined, as described in the preceding paragraph, to form zinc titanate.

The resulting zinc titanate is reduced to a suitable size for mixing with a hydrosol of alumina by any suitable method such as treatement in an ultrasonic disrupter. The zinc titanate may be reduced to any suitable size with a particle size in the range of about 1.0 to about 10 microns being preferred.

The resulting zinc titanate, having a fine particle size, is mixed with a hydrosol of alumina. Any suitable form of alumina may be utilized. Alumina hydrate is particularly prefererd because a hydrosol of alumina hydrate is readily converted to a hydrogel and then to the oxide phase after calcination.

After the zinc titanate has been thoroughly mixed into the hydrosol, a suitable base is added to convert the hydrosol to a hydrogel. Any suitable base such as alkali metal hydroxides, ammonium hydroxide, or urea may be

utilized. Ammonium hydroxide is the preferred base because it does not have any metallic component that would remain in the hydrogel.

The resulting hydrogel is dried slowly so that water will not be removed so rapidly that the hydrogel structure will collapse which would result in an excessive loss of pore volume and surface area in the finished hydrogel derived absorbing composition. Any suitable drying time can be utilized which does not result in too rapid removal of water. Preferably, the drying time is in the range of about 8 hours to about 24 hours.

Any suitable temperature can be utilized for the drying of the zinc titanate and alumina hydrogel but again the temperature should be such that too rapid a removal of water does not result. The temperature is preferably in the range of about 35°C to about 150°C. The most preferred drying condition is to start the drying process at about 80°C and increase the temperature slowly to about 120°C during the drying time.

After the zinc titanate and alumina hydrogel has been dried, it is then calcined in the presence of free oxygen to form the hydrogel derived absorbing composition. Any suitable free oxygen-containing gas may be utilized, with air being preferred because of its availability. Also, any suitable time and temperature for calcining may be utilized with a preferred time being about two hours and a preferred temperature being in the range of about 425°C to about 650°C and more preferably in the range of about 480°C to about 600°C. Although the dried zinc titanate and alumina hydrogel can be placed directly into a preheated furnace or kiln for calcining, it is preferable for the hydrogel to attain its final temperature during a heating period of about two hours.

In accordance with this invention, the hydrogel derived absorbing composition of zinc titanate and alumina must contain an amount of alumina in the range of about 10 weight-% to about 55 weight-% based upon the combined weight of the zinc titanate and alumina. The amount of alumina present in the hydrogel derived absorbing composition will more preferably be in the range of about 30 weight-% to about 50 weight-% based upon the combined weight of the zinc titanate and alumina.

The absorbing composition of the present invention is promoted with at least one metal selected from tungsten and molybdenum and at least one metal selected from Group VIII of the Periodic Table. Any suitable Group VIII metal may be used in accordance with this invention. Preferably, the

Group VIII metal is selected from the group consisting of iron, cobalt, nickel, ruthenium, rhodium and palladium. Of these metals, cobalt and nickel are the most preferred.

The promoters may be added to the absorbing composition either in their elemental form or in the form of suitable compounds.

Molybdenum compounds suitable for use as a promoter are ammonium molybdate, potassium molybdate, molybdenum sulfide, molybdenum oxides such as molybdenum (IV) oxide and molybdenum (VI) oxide, and the like, and mixtures of two or more thereof.

Tungsten compounds suitable for use as a promoter are ammonium tungstate, potassium tungstate, tungsten sulfide, tungsten oxides such as tungsten (IV) oxide and tungsten (VI) oxide, and the like, and mixtures of two or more thereof.

Metal compounds suitable for use as a promoter are metal acetates, metal carbonates, metal nitrates, metal oxides, metal sulfides, metal sulfates, metal thiocyanates, and the like, and mixtures of two or more thereof, wherein the metals are selected from Group VIII of the Periodic Table.

The promoting elements can be added to the absorbing composition by any method known in the art. The tungsten and/or molybdenum and at least one Group VIII metal may be added individually by impregnating the hydrogel with a solution, either aqueous or organic, that contains a promoting element. After the promoting element has been added to the hydrogel, the hydrogel is dried to remove essentially all of the solvent.

After drying the impregnated hydrogel, a solution of another promoting element may be added by impregnation if the tungsten or molybdenum and at least one Group VIII metal are not added in one step in the form of a metal tungstate or metal molybdate. The sequence in which the promoting elements are added is immaterial.

After the promoters have been added, the absorbing composition is calcined in the presence of oxygen at a temperature in the range of about 425°C to about 650°C until volatile matter is removed and the promoting metals are substantially converted to oxides. The time required for the calcining step will range from about 0.1 to about 10 hours.

Any suitable atomic ratio of tungsten and/or molybdenum to Group VIII metals may be utilized. The atomic ratio of tungsten and/or

molybdenum to Group VIII metals is generally in the range of from about 10:1 to about 1:3, and is more preferably in the range of from about 2:1 to about 10:7. In like manner, any suitable concentration of promoter metals may be utilized. The promoter metals will be present in the absorbing composition in the oxide form and the combined concentration of the tungsten oxide and/or molybdenum oxide and the Group VIII metal oxide will generally be in the range from about 2.0 weight-% to about 25 weight-% based upon the weight of the absorbing composition, and will more preferably be in the range of about 5.0 weight-% to about 15 weight-% based upon the weight of the absorbing composition.

The processes of the present invention can be carried out by means of any apparatus whereby there is achieved an alternate contact of the absorbing composition with the fluid feed stream and thereafter of the absorbing composition with a gas containing molecular oxygen which is utilized to regenerate the absorbing composition. The process is in no way limited to the use of a particular apparatus. The process of this invention can be carried out using a fixed absorbing composition bed, fluidized absorbing composition bed or moving absorbing composition bed. Presently preferred is a fixed absorbing composition bed.

In order to avoid any casual mixing of the fluid feed stream, containing the hydrogen sulfide, with the oxygen-containing gas utilized in the regeneration step, provision is preferably made for terminating the flow of the fluid feed stream to the reactor and subsequently injecting an inert purging fluid such as nitrogen, carbon dioxide or steam. Any suitable purge time can be utilized but the purge should be continued until all hydrocarbon and/or hydrogen are removed. Any suitable flow rate of the purge fluid may be utilized. Presently preferred is a purge fluid flow rate in the range of about 800 GHSV to abut 1200 GHSV.

Any suitable temperature for the processes of the present invention may be utilized. The temperature will generally be in the range of about 150°C to about 650°C and will more preferably be in the range of about 250°C to about 500°C.

Any suitable temperature may be utilized to regenerate the absorbing composition from its sulfided form back to the original absorbing composition form. The temperature will generally be in the range of about 370°C to about 815°C. A temperature of at least 540°C is preferred to effect the

conversion within a reasonable time.

Any suitable pressure for the processes of the present invention can be utilized. The pressure of the fluid feed stream being treated is not believed to have an important effect on the absorption process of the present invention. The pressure will be in the range of from about atmospheric to 2,000 psig (13.8 MPa) during the treatment, preferably 15 to 200 psig (107 to 1,379 kPa).

Any suitable residence time for the fluid feed stream in the presence of the absorbing composition of the present invention can be utilized. The residence time expressed as volumes of gas at standard temperature and pressure per volume of absorbing composition per hour will generally be in the range of about 10 to about 10,000 and will more preferably be in the range of about 250 to about 2,500.

When the absorbing composition is completely sulfided it will no longer combine with the hydrogen sulfide in the manner set forth in equation (I). When this condition occurs, hydrogen sulfide will begin to appear in the effluent flowing from the reaction and this will be an indication that the absorbing composition should preferably be regenerated. The time required for the absorbing composition to become completely sulfided will generally be a function of the concentration of sulfur in the feedstock and feed rate employed. Preferably the process is operated under conditions to reduce the H_2S concentration to less than about 75 ppm, preferably to less than about 50 ppm, in the time taken to load the absorbent with 4.0% by weight of sulfur.

When the absorbing composition becomes substantially completely sulfided, the absorbing composition is typically regenerated by terminating the flow of feed to the reactor and purging with an inert fluid such as nitrogen to remove any combustibles. A free oxygen-containing gas is then introduced to oxidize the zinc sulfide in accordance with equation (II). Also at the temperature at which the oxidation of the zinc sulfide is effected, the zinc oxide thus produced recombines with the titanium dioxide to resysnthesize the original zinc titanate in accordance with equation (III).

The amount of oxygen supplied during the regeneration step will generally be in an amount sufficient to at least substantially remove sulfur from the absorbing composition. The regeneration step is conducted at generally about atmospheric pressure. The temperature for the regenera-

tion step is preferably maintained in the range of about 370°C to about 815°C and is more preferably maintained at about 540°C in order to both oxidize the zinc sulfate and convert the zinc oxide and titanium dioxide to zinc titanate within a reasonable time. Suitable regeneration pressures are in the range atmospheric to 100 psig (690 kPa).

The following examples are presented in further illustration of the invention.

EXAMPLE I

In this example the experimental procedure for the removal of H_2S from gas streams by means of various solid sorbent materials is described.

The tests were carried out in a single reactor unit comprising a $\frac{3}{4}$" O.D. (19 mm) stainless steel reactor. The reactor, which was maintained at a pressure of about 9 psig (62 kPa), was operated in a fixed bed down flow mode using 20 cc of sorbent. Within the reactor, the sorbent was heated to the reaction temperature in a stream of nitrogen. When the desired temperature was attained, the nitrogen flow was stopped and the simulated Claus tail gas and, when used, water vapor flows were started. The water vapor was generated by pumping water through a heated line that was connected to the top of the reactor. The composition of the simulated Claus tail gas was controlled by mixing three feed gases. The compositions of the feed gases were as follows: (a) H_2S blend: 1.03 volume-% H_2S, 0.135 volume-% CS_2, 0.139 volume-% COS, balance N_2; (b) SO_2 blend: 1.22 volume-% SO_2, 2.93 volume-% CO, balance N_2; and (c) H_2.

The progress of the absorption was followed by measuring the H_2S concentration in the reactor effluent after the water vapor had been condensed and removed from the effluent. H_2S concentrations were measured with Draeger tubes suited to the concentration ranges encountered.

EXAMPLE II

This example described the sorbent materials which were tested in accordance with the procedures set forth in Example I.

Sorbent A: comprised $Co/Mo/Zn_2TiO_4$ with 3.1 weight-% Co (as CoO) and 8.3 weight-% Mo (as MoO_3). Sorbent A was prepared in the following manner: First, Zn_2TiO_4 was prepared essentially in accordance with the procedure set forth in the example of US Patent 4,376,698 (column

7 lines 20 to 31). Then a solution comprising 306 grams of $(NH_4)_6Mo_4O_{24}.4H_2O$ (lot KHLZ; Mallinckordt, Inc.; St. Louis, MO) in 2.0 litres of distilled water was added, with stirring, to 500.5 grams of Zn_2TiO_4. After 2 hours of intermittent stirring, the supernatant solution was decanted. The wet solid residue was dried on a hot plate for about 1 hour and then calcined at about 1000°F (982°C) for about 3 hours. To the thus heat treated Mo-impregnated Zn_2TiO_4 was added a solution comprising 272 grams of $Co(NO_3)_2.6H_2O$ (lot KHPA; Mallinckrodt, Inc.) in 2.0 litres of distilled water. After about 2 hours of intermittent stirring, the supernatant solution was decanted. The wet, solid residue was dried on a hot plate for about 1 hour and then calcined at about 1000°F (982°C) for about 3 hours. The BET/N_2 surface area of Sorbent A was about 10 m^2/g.

Sorbent B: comprised $Co/Mo/Zn_2TiO_4/Al_2O_3$ with 2.2 weight-% Co (as CoO), 10.8 weight-% Mo (as MoO_3), 55.9 weight-% Zn_2TiO_4 and 31.1 weight-% Al_2O_3. Sorbent B was prepared in the following manner: First, Zn_2TiO_4 was prepared by mixing zinc oxide and flame-hydrolyzed titania, drying the mixture and calcining it, essentially in accordance with the procedure described in Example 1 of US Patent 4,263,133. Then Zn_2TiO_4 was mixed with Al_2O_3 in accordance with the following procedure. About 80 grams of alpha-alumina monohydrate were dispersed in 1,500 mL of water with stirring. 10 mL of nitric acid were added to the suspension so as to lower the pH to about 1.4. After stirring for about 30 minutes, about 150 grams of Zn_2TiO_4 were added with stirring and the pH of the resulting slurry was adjusted to about 8.5 by adding, with stirring, 10 mL of NH_4OH. The formed Zn_2TiO_4/Al_2O_3 hydrogel was then transferred to an evaporating dish and dried at a temperature of about 75°C for about 20 hours and then at a temperature of 125°C for about 24 hours. The thus dried hydrogel was then calcined in the presence of a free-oxygen containing gas at a temperature of 1000°F (982°C) for about 2 hours.

The final steps of the preparation of sorbent B were carried out as follows. 50 grams of $(NH_4)_6Mo_7O_{24}.4H_2O$ were dissolved in 360 mL of distilled water with heating and stirring. Then 90 grams of the dried Zn_2TiO_4/Al_2O_3 gel were added to the solution. The slurry was intermittently stirred for about 2 hours and then allowed to settle. The supernatant solution was decanted, and the Mo-impregnated sorbent was dried at 120°C overnight and calcined at 1000°F (982°C) for 3 hours. The calcined material

was added to a solution of 48.4 grams of $Co(NO_3)_2.6H_2O$ in 360 mL with stirring. The Co, Mo-impregnated Sorbent B was then dried at 120°C and calcined at 1000°F (982°C) as outlined above. The BET/N_2 surface area of Sorbent B was 88 m^2/g.

Sorbent C: comprised $Ni/Mo/Zn_2TiO_4/Al_2O_3$ with 2.2 weight-% Ni (as NiO), 10.8 weight-% Mo (as MoO_3), 55.9 weight-% Zn_2TiO_4 and 31.1 weight-% Al_2O_3. Sorbent C was prepared in the same manner as Sorbent B.

Sorbent D: comprised $Co/Mo/Zn_2TiO_4/Al_2O_3$ with 2.4 weight-% Co (as CoO), 8.0 weight-% Mo (as MoO_3), 48.4 weight-% Zn_2TiO_4 and 41.2 weight-% Al_2O_3. Sorbent D was prepared in the same manner as Sorbent B except that 115 grams of alpha-alumina monohydrate and 115 grams of Zn_2TiO_4 were employed in forming the hydrogel.

Sorbent E: comprised $Co/Mo/Zn_2TiO_4/Al_2O_3$ with 2.6 weight-% Co (as CoO), 6.5 weight-% Mo (as MoO_3), 35.0 weight-% Zn_2TiO_4 and 55.9 weight-% Al_2O_3. Sorbent E was also prepared in the same manner as Sorbent B except that 150 grams of alpha-alumina monohydrate and 80 grams of Zn_2TiO_4 were employed in forming the hydrogel.

Sorbent F: comprised $Co/Mo/Zn_2TiO_4/Al_2O_3$ with 5.1 weight-% CoO, 15.0 weight-% MoO_3, 5.2 weight-% ZnO, 2.8 weight-% TiO_2 and 71.9 weight-% Al_2O_3. Sorbent F was prepared by impregnating a Co/Mo-promoted Al_2O_3 support with Zn and Ti and then calcining the thus impregnated Al_2O_3 support, essentially in accordance with the procedure set forth in Example I of US Patent 4,287,050.

Sorbent G: comprised $Co/Mo/Al_2O_3$ with 3.2 weight-% Co and 7.8 weight-% Mo (BET/N_2 surface area: 282 m^2/g; marketed as Ketjen K-124-LD by Armak Catalyst Division of Akzona, Inc., Pasadena, TX).

EXAMPLE III

This example illustrates the use of the sorbents described in Example II within the procedure described in Example I for the removal of H_2S from a simulated wet Claus process off-gas (Claus tail gas). For runs 1, 3, 4, 6 and 7 the Claus tail gas comprised 4800 ppm H_2S, 2820 ppm SO_2, 650 pm COS, about 650 ppm CS_2, 0.68 volume-% CO, 27.7 volume-% H_2O vapor and 67.8 volume-% N_2. For runs 2 and 5 the Claus tail gas comprised 10,700 ppm H_2S, 27 volume-% H_2O and 72 volume-% N_2. Due to the differences in the two feeds, the results are presented as a function of the amount of

sulfur (measured as a weight-% based upon the weight of the absorbing composition) absorbed by the absorbing composition as of the time of the reading. The test results are summarized in Table I.

TABLE I

Run	Sorbent	Zn_2TiO_4: Al_2O_3 Ratio	Temp (°C)	GHSV[a]	Run Time (min.)	Absorbed Sulfur[b] (wt-%)	PPM H_2S in Product	%-Removal of H_2S
1 (Control)	A	100:0	357	2000	30	1.11	5	~100
					90	3.33	677	86
					180	6.66	3,279	32
2 (Invention)	B	65:35	399	1000	30	.75	1	~100
					60	1.50	1	~100
					80	2.00	1	~100
					120	3.00	1	~100
					150	3.83	17	~100
					180	4.50	550	89
					225	5.40	1200	75
3 (Invention)	C	65:35	399	1000	38	.91	60	99
					75	1.80	30	99
					141	3.46	21	~100
					204	5.00	16	~100
					259	6.33	28	99
					320	7.78	130	97
					383	9.23	600	88
4 (Invention)	D	54:46	357	2000	30	1.10	0	100
					90	3.31	~4	~100
					130	4.81	42	99
					180	6.09	3,015	37
5 (Control)	E	38:62	357	1000	30	.71	87	98
					60	1.42	90	98
					105	2.70	468	90
					125	3.00	2930	39
6 (Control)	F	10:90	360-380	1000	25	.63	21	~100
					70	1.75	310	94
					115	2.73	900	81
7 (Control)	G	0:100	360	2000	20	1.06	748	84
					60	2.89	1,082	77
					160		1,695	65
					350		2,922	39

a) Gas Hourly Space Velocity (cc/cc catalyst/hr)
b) Based upon the weight of the absorbing composition

In comparison with run 1 (Control, no alumina), runs 2 to 4 show that the addition of alumina, in a weight ratio relative to Zn_2TiO_4 of 35:65 and 46:54 respectively, to the absorbing compositions substantially increased the absorbing compositions' effectiveness in removing hydrogen sulfide from a fluid feed stream. The results of runs 5 to 7, however, show that the addition of alumina in weight ratios relative to Zn_2TiO_4 in excess of about 62:38 had no such beneficial effect. Based upon these results, it is believed that a concentration of alumina in the inventive absorbing composition in the range of about 10 weight-% to about 55 weight-% is critical to the invention, with the most preferred range being about 30 weight-% to about 50 weight-%.

EXAMPLE IV

This example illustrates the removal of H_2S from a dry gas comprising 0.7 weight-% (7,000 ppm) H_2S, 0.1 weight-% COS, 0.1 weight-% CS_2 and 99.1 weight-% N_2. This gas was passed through the sorbent bed at a GHSV of about 2,000 cc/cc catalyst/hr. The test results are summarized in Table II.

TABLE II

Run	Sorbent	ZnTi:Al Ratio	Temp (°C)	Run Time (min.)	PPM H_2S in Product	%-Removal of H_2S
7 (Control)	A	100:0	357	60	10	99.9
				120	45	99
				150	159	98
				210	845	88
				250	1,246	82
				280	1,822	74
8 (Invention)	D	54:46	357	30	0	100
				85	1	100
				120	1	100
				165	272	96
				175	874	88
				205	2,495	64
				240	4,460	36

The results of runs 7 and 8 clearly show that in the first two hours on stream Sorbent D, containing a weight ratio ZnTi:alumina 54:46, was considerably more effective in removing H_2S from a dry feed gas than control Sorbent A. A comparison of the results of runs 7 and 8 with those of runs 1 and 3, which are set forth in Table I, further shows that the inventive absorbing compositions are more effective at removing hydrogen sulfide from a dry feed gas than from a wet feed gas.



CLAIMS

1. A process for the removal of hydrogen sulfide from hydrogen sulfide-containing fluid streams which comprises contacting the fluid stream with a hydrogen sulfide-absorbing composition, wherein the hydrogen sulfide-absorbing composition comprises zinc titanate and alumina promoted with (a) one or both of tungsten and molybdenum and (b) at least one metal selected from Group VIII of the Periodic Table, the concentration of alumina in said absorbing composition being in the range 10 to 55 weight-%, based upon the combined weight of the zinc titanate and alumina, the promoters being present in the absorbing composition in oxide form.

2. A process according to claim 1, wherein the concentration of alumina in the absorbing composition is in the range 30 to 50 weight-%, based upon the combined weight of the zinc titanate and alumina.

3. A process according to claim 1 or 2, wherein the combined concentration of the promoters (a) and (b), calculated as oxides, in said absorbing composition is in the range 2 to 25 weight-%, based upon the weight of the absorbing composition.

4. A process according to claim 3, wherein said concentration is in the range 5 to 15 weight-%, based upon the weight of the absorbing composition.

5. A process according to any one of the preceding claims, wherein the atomic ratio of said tungsten and/or molybdenum to said Group VIII metal(s) in said absorbing composition is in the range 10:1 to 1:3.

6. A process according to claim 5, wherein said atomic ratio is in the range 2:1 to 10:7.

7. A process according to any one of the preceding claims, wherein the atomic ratio of zinc to titanium in said zinc titanate is in the range 1:1 to 3:1.

* C L M S *

8. A process according to claim 7, wherein said atomic ratio of Zn:Ti is in the range 1.8:1 to 2.2:1.

9. A process according to any one of the preceding claims, wherein the hydrogen sulfide-containing fluid is contacted with the absorbing composition at a temperature in the range 150°C to 650°C, at a total system pressure in the range atmospheric to 2000 psig (13.8 MPa) and at a residence time in the range 10 to 10,000 volumes of said fluid stream (measured at standard temperature and pressure) per volume of said absorbing composition per hour.

10. A process according to claim 9, wherein the contact temperature is in the range 250°C to 500°C, the total system pressure is in the range 15 to 200 psig (107 to 1379 kPa) and the residence time is in the range 250 to 2,500 volumes of said fluid stream (calculated at standard temperature and pressure) per volume of said absorbing composition per hour.

11. A process according to any one of the preceding claims, which includes periodically regenerating the absorbing composition by discontinuing the flow of said fluid stream over said absorbing composition and contacting said absorbing composition at an elevated temperature and after the flow of said fluid stream is discontinued, with a molecular oxygen-containing regenerating fluid.

12. A process according to claim 11, wherein the regeneration conditions comprise a feed rate of said molecular oxygen-containing fluid suitable sufficient to remove substantially all of the sulfur from said absorbing composition, a temperature in the range 370°C to 815°C, and a pressure in the range atmospheric to 100 psig (690 kPa).

13. A process according to claim 12, wherein the regeneration process additionally comprises purging said absorbing composition with an inert fluid before contacting said absorbing composition with said oxygen-containing fluid.

14. A process according to any one of the preceding claims which is

* C L M S *

effective to reduce the concentration of hydrogen sulfide in said fluid stream to less than about 75 ppm in the time taken to load the absorbing composition with 4.0 weight-% sulfur.

15. A process according to claim 14, which is effective to reduce the concentration of hydrogen sulfide in said fluid stream to less than about 50 ppm in the time taken to load the absorbing composition with 4.0 weight-% sulfur.

16. A sulfide absorbent composition comprising zinc titanate and alumina in an amount of from 10 to 55% by weight, based on the combined weight of zinc, titanium and alumina, said composition additionally comprising, as promoters, one or both of molybdenum and tungsten, and at least one metal from Group VIII of the Periodic Table, said promoters being present in said composition in oxide form.

17. A composition according to claim 16, wherein said Group VIII metal is cobalt or nickel.

18. A composition according to claim 16 or 17, wherein the zinc titanate comprises a Zn:Ti atomic ratio in the range 1:1 to 3:1.

19. A composition according to claim 18, wherein said Zn:Ti atomic ratio is in the range 1.8:1 to 2.2:1.

20. A composition according to any one of claims 16 to 19, wherein the atomic ratio of tungsten and/or molybdenum to Group VIII metal is in the range 10:1 to 1:3.

21. A composition according to claim 20, wherein said ratio of tungsten and/or molybdenum to Group VIII metal is in the range 2:1 to 10:7.

22. A composition according to any one of claims 16 to 21, wherein the combined concentration of tungsten and/or molybdenum and the Group VIII metal, calculated as oxides, is in the range 2 to 25% by weight, based on the weight of the total composition.

* C L M S *

23. A composition according to claim 22, wherein the combined weight of tungsten and/or molybdenum and the Group VIII metal, calculated as oxides, is in the range 5 to 15% by weight based on the total composition.

24. A composition according to any one of claims 16 to 23 wherein the alumina is present in an amount of from 30 to 50% by weight, based on the total weight of zinc, titanium and alumina.

25. A process for the preparation of a sulfide absorbent composition as claimed in any one of claims 16 to 24, which comprises forming a hydrogel comprising zinc titanate and alumina, drying the hydrogel, incorporating the promoters into the dried hydrogel, and calcining the resulting product to convert the promoters into oxide form.

26. A process according to claim 25, wherein the sulfide-absorbing composition is prepared by calcining a mixture of zinc oxide and titanium dioxide in the presence of free oxygen at a temperature in the range 650°C to 1050°C to form zinc titanate, mixing the thus formed zinc titanate in a powdered form with a hydrosol of alumina hydrate to form a zinc titanate-alumina hydrosol, adding ammonium hydroxide to convert said hydrosol to a hydrogel, drying and calcining said hydrogel to form a hydrogel derived composition of zinc titanate and alumina, adding the promoters to said hydrogel derived composition of zinc titanate and alumina, and calcining the resultant composition to provide said promoters in said composition in oxide form.

27. A process according to claim 26, wherein there is used an absorbing composition prepared by a process as defined and in which said hydrogel of zinc titanate and alumina is dried for a time in the range 8 hours to 24 hours and at a temperature in the range 35°C to 150°C prior to the addition of said promoters.

28. A process according to claim 27, wherein the dried hydrogel of zinc titanate and alumina is calcined in the presence of free oxygen at a temperature of from 425°C to 650°C for about 2 hours.

* C L M S *

29. A process according to claim 26, 27 or 28, wherein there is used an absorbing composition prepared by a process as defined and in which the composition of zinc titanate and alumina to which said promoters have been added is calcined in the presence of free oxygen at a temperature in the range 425°C to 650°C for a time in the range 0.1 hours to 10 hours.

30. A process according to any one of claims 1 to 15, wherein there is used a sulfide-absorbing composition prepared by a process claimed in any one of claims 25 to 29.