A catalyst for the combination of CO and O₂ to form CO₂ which includes a platinum group metal—e.g., platinum; a reducible metal oxide having multiple valence states—e.g., SnO₂; and a compound which can bind water to its structure—e.g., silica gel. This catalyst is ideally suited for application to high-powered, pulsed, CO₂ lasers operating in a sealed or closed-cycle condition.

5 Claims, No Drawings
1

CATALYST FOR CARBON MONOXIDE OXIDATION

ORIGIN OF THE INVENTION

The invention described herein was made jointly in the performance of work under a NASA contract and employees of the U.S. Government. In accordance with 35 USC 202, the contractors elected not to retain title.

CROSS REFERENCE TO RELATED APPLICATION

This application is related to co-pending applications Ser. No. 07/090,874, filed Aug. 31, 1987 now U.S. Pat. No. 4,855,274.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to a catalyst for the combination of CO and O2 to form CO2. It relates particularly to a catalyst for combining CO and O2 to form CO2 in a high-powered, pulsed CO2 laser.

2. Description of the Related Art

In many applications, it is highly desirable, even necessary, to operate a CO2 laser in a sealed condition, for in an open system the laser requires a continuous flow of laser gas to remove the dissociation products—viz., CO and O2—that occur in the discharge zone of the laser, in order to maintain a stable power output. This adds to the operating cost of the laser, and in airborne or space applications, it also adds to the weight penalty of the laser. In a sealed CO2 laser, a small amount of CO2 gas is decomposed in the electrical discharge zone into corresponding quantities of CO and O2. As the laser continues to operate, the concentration of CO2 decreases, while the concentrations of CO and O2 correspondingly increase. The increasing concentration of O2 reduces laser power, because O2 scavenges electrons in the electrical discharge, thereby causing arcing in the electric discharge and a loss of the energetic electrons required to boost CO2 molecules to lasing energy levels. As a result, laser power decreases rapidly. It is known that the output of a sealed CO2 laser can be enhanced by the addition of a small amount of water vapor to the laser gas. See W. J. Witteman, “The CO2 Laser”, Vol. 53, Springer-Verlag (1987), pp. 104–108. However, this is a short-term effect, after which output starts to fall. Additionally, too much water vapor in the gas will decrease the laser output. See W. J. Witteman, “Increasing continuous laser-action on CO2 rotational vibrational transitions through selective depopulation of the lower laser level by means of water vapor,” Physics Letters, Vol. 18, No. 2, Aug. 15, 1965; and Witteman, W. J., “4B4-Rate determining processes for the production of radiation in high power molecular lasers,” IEEE J. of Quantum Electronics, Vol. QE-2, No. 9, September 1966.

A catalyst that can combine CO and O2 as soon as formed in the laser envelope would prevent the loss of laser power. To be effective, many catalysts must be heated to elevated temperatures above ambient conditions to efficiently combine the products of CO2 dissociation. This is not feasible in the laser envelope, because the gas in this envelope must be maintained at ambient temperature for efficient operation. This means that the catalyst must be located in a recirculating loop external to the laser; and this requires a pump, a heating system, and a cooling system, all of which can add to operating cost, as well as to weight penalty in airborne or space-borne applications. However, a catalyst effective at ambient operating temperatures can be installed directly in the laser envelope, since the laser gas, comprising CO2, N2, and He, is under high circulation at ambient temperature. Many catalysts require either regeneration or replacement, because they degrade with time and lose their activity for combining the CO2 dissociation products. These requirements not only add to the operating cost and weight penalty of the laser, but also render space-borne applications unfeasible. However, if the ambient-temperature catalyst maintains its activity for long periods of time, a laser can be operated economically in ground-based, airborne, and space-borne applications.

Catalyst formulations of the related prior art consist of (1) a dispersion of colloidal and noncolloidal particles of stannic oxide, either self-supporting or impregnated on an inert support, with a noble metal on the stannic oxide surface (see U.S. Pat. No. 4,524,051) and (2) particles, granules or pellets of stannic oxide with a noble metal on the stannic oxide surface (see European Patent Application No. 83306312.6, dated Oct. 18, 1983).

One of the primary disadvantages of the related prior art is that when the stannic oxide catalyst is in the form of particles, granules, pellets, or supports impregnated with colloidal particles, most of the stannic oxide is below the surface, is structurally bound to other stannic oxide molecules, and is therefore unavailable as active sites. Thus, there is a relatively small surface area of stannic oxide available as active sites for catalytic activity.

Another primary disadvantage of the related prior art is that there is no comprehension of using chemisorbed moisture on a Pt/SnO2 catalyst surface to enhance and prolong its activity.

SUMMARY OF THE INVENTION

It is accordingly the primary object of the present invention to provide what the prior art has been unable to provide, viz., a catalyst which, by composition of matter alone, contains chemisorbed water within and upon its structure, depending upon the treatment conditions to which it is exposed prior to its application, such bound moisture rendering the catalyst highly active and very long-lived, such that only a small quantity of it need to be used internally or externally to a sealed or closed-cycle CO2 laser under ambient operating conditions therein for extended time periods, small concentrations of laser dissociation products, viz., CO and O2, being combined to form CO2.

This primary object and other objects and benefits are achieved by the provision of a catalyst which consists essentially of about 1 to 40 percent by weight of one or more platinum group metals (Pt, Pd, Rh, Ir, Ru, Os, platinum being preferred); about 1 to 90 percent by weight of one or more oxides of reducible metals having multiple valence states (such as Sn, Ti, Mn, Cu, and Ce, with SnO2 being preferred); and about 1 to 90 percent by weight of a compound which can bind water to its structure (such as silica gel, calcium chloride, magnesium sulfate, hydrated alumina, and magnesium perchlorate, with silica gel being preferred). Especially beneficial results are obtained when platinum is present in the catalyst composition in an amount of about 5 to 25 (especially 7 percent by weight, SnO2 is present in an amount of about 30 to 40 (especially 40) percent by
The second step is accomplished by preparing an aqueous mixture of the tin(IV) oxide coated silica gel and a soluble, chloride-free salt of at least one platinum group metal. Extremely beneficial results have been obtained using chloride-free salts of platinum, palladium, or a combination thereof, such as tetraamine platinum(II) hydroxide (Pt(NH₃)₄(OH)₂) or tetraamine palladium(II) nitrate (Pd(NH₃)₄(NO₃)₂). It is also beneficial if the coated silica gel is first deaerated by boiling. The platinum group metal salt is adsorbed onto the high surface area and coats the surface. Any excess oxidizing agent is then evaporated, and the resulting metatannic acid-coated silica gel is dried, whereby the metatannic acid becomes tin(IV) oxide (SnO₂).

The present invention has been described in detail with respect to certain preferred embodiments thereof. However, as is understood by those of skill in the art, variations and modifications in this detail can be made without any departure from the spirit and scope of the present invention as defined in the hereto-appended claims.

What is claimed is:

1. A catalyst for the combination of CO and O₂ to form CO₂, the catalyst consisting essentially of about 1 to 40 percent by weight of a platinum group metal, about 1 to 90 percent by weight of a reducible metal oxide, such as tin(IV) oxide, and about 1 to 90 percent by weight of a compound which can bind water to its structure selected from the group consisting of Sn, Mn, and Cu, and which can bind water to its structure selected from the group consisting of silica gel, calcium chloride, magnesium sulfate, hydrated alumina, and magnesium perchlorate. This catalyst can be in the form of granules, beads, pellets or monoliths. The size and shape of the particles can vary, although a uniform size and shape are desirable properties for good flow distribution through a bed or structure of these particles. The water content of the silica gel has varied up to 27%.

2. The catalyst of claim 1, wherein the platinum group metal has been deposited onto the tin(IV) oxide coated silica gel, the solution is evaporated to dryness, and the desired catalyst is obtained.

3. The catalyst of claim 1, wherein the platinum group metal is platinum, the reducible metal oxide having multiple valence states is SnO₂, and the compound which can bind water to its structure is silica gel.
4. The catalyst of claim 3, wherein the platinum is present in an amount of about 5 to 25 percent by weight, the SnO₂ is present in an amount of about 30 to 40 percent by weight, and the silica gel is present in an amount of about 45 to 55 percent by weight.

5. A catalyst for the combination of CO and O₂ to form CO₂ in a sealed CO₂ laser, the catalyst consisting essentially of about 7 percent by weight of platinum, about 40 percent by weight of SnO₂, and about 50 percent by weight of silica gel.