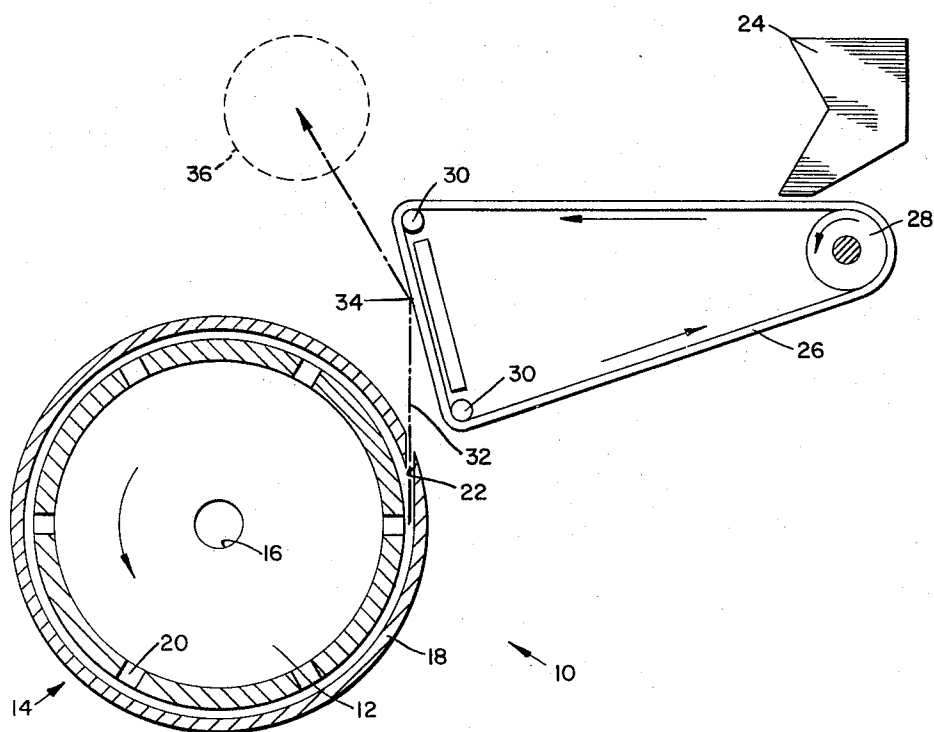


March 7, 1967

M. VON ARDENNE

3,308,292

APPARATUS FOR VAPORIZATION OF POLYATOMIC MOLECULES
BY BOMBARDMENT WITH A NEUTRAL PARTICLE BEAM
Filed March 25, 1964



INVENTOR.
MANFRED VON ARDENNE

1

3,308,292

APPARATUS FOR VAPORIZATION OF POLY- ATOMIC MOLECULES BY BOMBARDMENT WITH A NEUTRAL PARTICLE BEAM

Manfred von Ardenne, Zeppelinstrasse 7, Dresden-
Weisser Hirsch, Germany

Filed Mar. 25, 1964, Ser. No. 356,003

8 Claims. (Cl. 250—41.9)

The present invention relates to a method and apparatus for the vaporization of polyatomic molecules at a low dissociation coefficient. The method and apparatus may be utilized in the analysis of organic materials of high molecular weight in molecular mass spectrographs, and for chemical separation of molecules with different molecular weights.

At the present time, thermal processes are employed in the vaporization of polyatomic molecules. The conventional vaporization method is dependent upon the transfer of energy to the particles of matter which are to be vaporized and the distribution of energy corresponding to Maxwell's distribution. Thus, the energy values involved in thermal vaporization fluctuate within a very wide range. A satisfactory molecular vaporization may often occur at a low value of mean energy according to the Maxwell distribution. However, the large number of high energy particles included in the distribution dissociate the molecules of the substances to be vaporized, i.e., break the molecules up into fragments.

Hence, where conventional thermal vaporization is employed, the degree of dissociation increases as the difference between the amount of energy necessary to effect separation and the smallest amount of energy necessary to effect dissociation becomes smaller, i.e., the greater the number of atoms which are combined in a given molecule. Thus, it is difficult to effect separation without dissociation because of the wide range of energy which is employed in conventional methods.

Accordingly, the object of this invention is to vaporize polyatomic molecules with reduced dissociation of the molecules.

It is also an object of the present invention to provide a method and apparatus for supplying a narrow range of energy for the vaporization of various materials.

The present invention utilizes an ultracentrifuge which is adapted to accelerate and eject atoms, e.g. mercury at a target. The target may be a solid or liquid monomolecular or ultrathin layer of material which is bombarded by the atoms of mercury. A loading or charging means delivers the target material to a continuous belt, which in turn, delivers the material to the target area. The target and ejection angle of the mercury atoms may be arranged to guide the vaporized molecules into a negative charge carrier storage space of the ion source of a molecular mass spectrograph.

Other objects of this invention will be apparent from the following description and claims, and may be understood by reference to the accompanying drawing, which by way of illustration shows a preferred embodiment of the invention and what is now considered to be the best mode of applying the principles thereof.

In the drawings:

The drawing is a schematic representation of apparatus according to the invention employed in the impact vaporization of polyatomic molecules.

The apparatus includes an ultracentrifuge indicated at 10. Such ultracentrifuges are known and may be found in the following publications: Svedberg-Pedersen, *The Ultracentrifuge*, Oxford University Press, New York, 1940; Beams, *Report on Progress in Physics*, 8, 31, 1941; Pickles in *Corcoran, Methods in Medical Research*, 5,

2

Year Book Publication, Chicago, 107, 1952; Beams et al., *Proceedings Second International Conference, Geneva 1958*, 4, 428, 1958; Schachman, *Ultracentrifugation in Biochemistry*, Academy Press, New York, 1959.

A rotor 12 of ultracentrifuge 10 is provided with an axial bore 16. The rotor is enclosed by a housing 18 and includes a plurality of radial sheathing bores 20 arranged in spaced equidistant intervals. An ejection orifice 22 is cut from housing 18. By way of example the rotor diameter may be 10 mm. and its angular velocity 10^6 r.p.m. Preferably, rotor 12 may consist of a whisker material including plastic or metallic reinforcements to increase the speed by a factor between five and ten.

A loading or charging device 24 is adapted to deliver target material to an endless conveyer belt 26. Conveyer belt 26 is driven by a friction roller 28 which is rotated by suitable drive means (not shown). Pulleys 30 are provided at the portion of the belt which includes the target area to provide a suitable guide for the belt.

Vapors of a material having high atomic weight, for example mercury vapors, are continuously fed by supply means (not shown) through axial bore 16 into rotor 12 of the ultracentrifuge. The mercury atoms of the vapor are directed outwardly from the center to the periphery of the rotor by the centrifugal force produced by the spinning rotor. The mercury atoms are thereby moved through the sheathing bores 20 and orifice 22. The impetus imparted to the atoms by the spinning rotor determines the energy values of the particles ejected through orifice 22, which is formed to direct a tangential flow 32 towards the target 34. Belt 26 which is continuously charged with the material to be vaporized carries the material from the charging device 24 through the target area 34. The material to be used as a target may be solid or liquid monomolecular or ultrathin layer of the material, or an obliquely bombarded thicker (liquid) layer.

Beam 32 consists of uniform highly accelerated mercury atoms, which when they impinge upon the target area vaporize the material thereon. The energy of the mercury atoms is always transferred to the entire molecule upon which they impinge. The vaporization of the material takes place without any dissociation of the molecules because the energy values of the narrow energy distribution provided by the instant apparatus may be maintained below the energy values necessary to dissociate the molecules, since the energy values of the neutral atoms may be readily controlled by varying the angular velocity of rotor 12.

By keeping target area 32 in close proximity to ejection orifice 22 dispersement of the bombarding particles is inhibited preventing these particles from impinging upon other neutral particles at the vapor pressure within the centrifuge, e.g. .001 mm. of mercury.

Furthermore, the amount of energy necessary to effect separation may be reduced by effecting vaporization at corners or edges of the target.

The embodiment disclosed in the present invention may be utilized to enlarge the scope of conventional molecular mass spectroscopy, wherein negative charge carriers are deposited on the vaporized test molecules. When the apparatus is used in this manner the vapor particles of the vaporized material are guided by beam 32 into a charge carrier storage space 36 of the ion source of a molecular mass spectrograph (not shown), arranged in close proximity to target area 34. Electrons or negative OH ions, for example, stored in space 36 are attracted to the non-dissociated polyatomic molecules transmitted to the storage space from the target area. Neutral molecules therefore

are converted into negative ions (the mass of the molecules being increased by the OH ion mass). The resultant molecule ions are removed from the storage space by the electrical field of the molecular mass spectrograph, accelerated and split-up in the magnetic field. A mass spectrum results thereby, the instant invention preventing the decomposition of the primary molecules, as would be the case with some of the molecules in the conventional thermal vaporization method.

The present invention thus enables the spectrographical mass analysis of natural substances and mixtures of such substances with higher molecular weight (especially natural substances of human, animal and vegetable origin) which would be decomposed if subjected to thermal vaporization. Thus, the invention may be utilized to examine blood serum, even in a dried state.

The invention may also be employed for the partial or complete separation of complicated organic molecular mixtures.

The ultracentrifuge system may be modified to accommodate the various objectives of the inventive features described herein. Thus, if the invention is used as an ancillary apparatus for a charge carrier-ion source storage, rotor 12 is made very short and provided with circumferential bores. When the invention is utilized as a material separating device for industrial or laboratory use, the rotor is made longer, and includes a large number of bores enclosed by an extensive collecting baffle. Cascading may be employed to increase the separating effect.

In summary the present invention provides a beam of particles whose energy value may be adjusted to a predetermined range. The narrow range of energy values allows the target material to be bombarded with particles having an energy value higher than the amount necessary to effect separation, yet lower than the lowest amount of energy which would cause dissociation of the target material. Thus, organic materials of high molecular weight may be analyzed in molecular mass spectrographs and an improved chemical separation of molecules with different molecular weights may be attained.

I have described what I believe to be the best embodiments of my invention. I do not wish, however, to be confined to the embodiments shown, but what I desire to cover by Letters Patent is set forth in the following claims.

What is claimed:

1. Apparatus for the vaporization of polyatomic molecules comprising an ultracentrifuge, a target area, and means for supplying material to be vaporized to said target area, said ultracentrifuge including means for directing

neutral particles at said material in the target area to thereby effect vaporization of said material.

2. Apparatus according to claim 1, wherein said means for directing comprising a rotor and an apertured sheathing about said rotor.

3. Apparatus according to claim 2, wherein said rotor consists of a whisker material and reinforcing means therefor.

4. Apparatus according to claim 2, wherein the radial sheathing bores of said rotor feature a special geometry for discrimination against all electrically neutral particles whose energy is above the nominal value.

5. Apparatus according to claim 2, wherein said target area and means for supplying comprises an endless belt, a portion of which is always in close proximity to the ejection orifice of said ultracentrifuge.

6. Apparatus according to claim 5, wherein the material to be vaporized is applied to said belt in a thin layer.

7. Apparatus according to claim 1, including charge carrier storage means of a mass spectrograph for receiving the vaporized molecules.

8. Vaporization apparatus comprising an ultracentrifuge, said ultracentrifuge including a rotor having radially directed sheathing bores, a bore extending in a direction perpendicular to the radial direction of said rotor, a housing having an ejection orifice therein encompassing said rotor, whereby bombarding particles may be delivered through said perpendicular bore to said rotor and accelerated therein and delivered through the ejection bore, a charging container having target material therein, a friction roller and a plurality of guard rollers, an endless belt arranged around said friction roller and guard rollers whereby said friction roller may move said endless belt, a charging container being adapted to feed the target material onto said endless belt, said endless belt being adapted to carry the target material to a target area, said target area being in close proximity to the ejection orifice, whereby particles directed through said ejection orifice impinge the target material in the target area, thereby effecting vaporization of the target material without the dissociation thereof.

References Cited by the Examiner

UNITED STATES PATENTS

2,703,843	3/1955	Cameron	250—41.9
3,046,936	7/1962	Simons	118—49.1

RALPH G. NILSON, *Primary Examiner*.

A. L. BIRCH, *Assistant Examiner*.