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(54) **METHODE ET COMPOSITION POUR LA PRECIPITATION DE
L'EAU ATMOSPHERIQUE**

(54) **METHOD AND COMPOSITION FOR PRECIPITATION OF
ATMOSPHERIC WATER**

(57) A method for precipitating atmospheric water by means of multicomponent aerosols, including iodide based complex multicomponent aerosol compositions. The compositions comprise a solid mass formed by a compacted mixture of silver iodide and the iodides, iodates, and periodates of alkali metals, lead, copper, barium; ammonia, barium chromate, and selected oxidizers such as ammonium perchlorate, and fuels such as poly-p-phenylene, phenol formaldehyde resin, epoxide resin, and shellac and mixtures thereof. The compositions, upon burning, produce an aerosol effective to promote atmospheric water precipitation.



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ABSTRACT OF THE DISCLOSURE

10 A method for precipitating atmospheric water by means
of multicomponent aerosols, including iodide based complex
multicomponent aerosol compositions. The compositions
comprise a solid mass formed by a compacted mixture of
silver iodide and the iodides, iodates, and periodates of
15 alkali metals, lead, copper, barium; ammonia, barium
chromate, and selected oxidizers such as ammonium
perchlorate, and fuels such as poly-p-phenylene, phenol
formaldehyde resin, epoxide resin, and shellac and
mixtures thereof. The compositions, upon burning, produce
20 an aerosol effective to promote atmospheric water
precipitation.

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**A METHOD OF PRECIPITATION OF ATMOSPHERIC WATER BY MEANS
OF MULTICOMPONENT AEROSOLS**

The field of invention: A 01 g 15/00

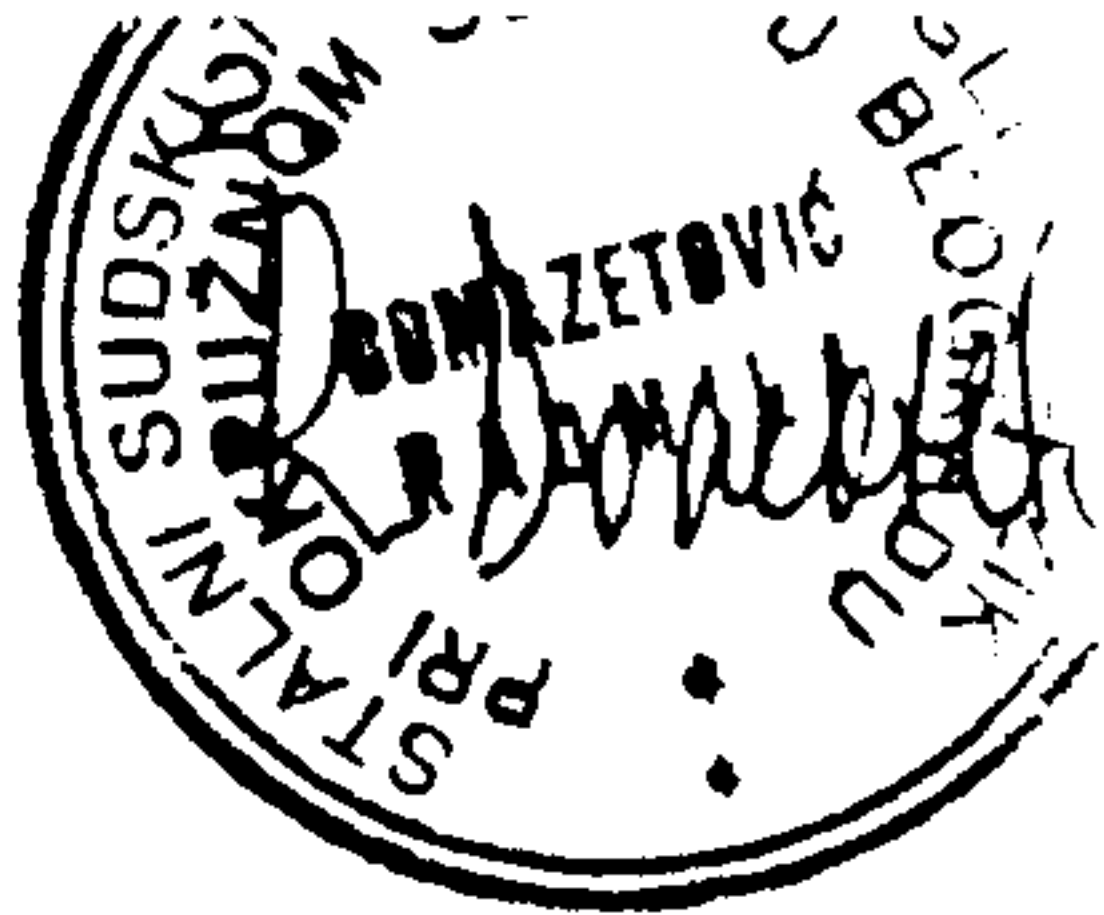
Background of the invention

5 In the both patent and scientific literature a number of weather modification methods was reported, consisting in the seeding of moist atmosphere by aerosols of different chemical composition, both organic and inorganic, the purpose of the seeding being hail suppression, rain regulation or fog precipitation.

10 In general, aerosols act as active centers of heterogeneous nucleation of atmospheric water, causing the local drop in water vapour pressure around them, what leads in addition to a continuous growth of water droplets or ice crystals. The number of active centers of nucleation developed by dispersion of a nucleant mass unit is used as a measure of its weather modification effectiveness.

15 The highest sofar known effectiveness was achieved by the use of silver iodide as a nucleant. Although silver iodide is a rather expensive chemical, if the total costs of dispersion into atmosphere of different nucleants are compared, the weather modification by silver iodide seems to be the most economical.

20 For the weather modification purposes, silver iodide aerosol is developed by burning liquid solutions or solid pyrotechnical mixtures having silver iodide as a constituent. The mixtures generating pure silver iodide aerosol are generally much less effective than those generating composite aerosols.



Pure silver iodide aerosol is practically ineffective above -5°C . Burkhardt et al. (US Patent 3,915,379) have reported that two-component aerosols of the composition AgI-MI, where M is alkali metal, show markedly more pronounced nucleation ability than that of pure silver iodide. DeMott et al. (P.J.DeMott, W.G.Finnegan and L.O.Grant, J.Clim.Appl. Met., 22 (1983) 1190) have shown that the effectiveness of aerosol developed by burning acetone solution was considerably improved when the solution contained additives which enable aerosol to be a complex mixture AgI-AgCl-NaCl. However, the improvement was realised in such a way at temperature below -10°C only, while at -5°C aerosol is practically ineffective.

Solid pyrotechnical mixtures based on silver iodide reported so far in the patent and other literature, as compared to liquid solutions, generate aerosols of an improved effectiveness in the vicinity of a threshold temperature of -5°C , which means a more uniform nucleation ability within the whole temperature range interesting from the standpoint of weather modification. An additional advantage of solid mixtures is a broader list of ways of dispersing them into clouds: by means of airplanes, rockets, artillery shells and ground placed generators. Liquid solutions can be used only by means of airplanes and ground placed generators.

The increase of the yield of active nuclei per mass unit of silver iodide, the shift of a threshold temperature as near as possible to 0°C , and adjustment of dispersion methods to comply to the requirements of weather modification, represent a permanent task in the field of weather modification.



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Summary of the invention

A method of precipitation of atmospheric water from the temperature zones below 0°C has been found, consisting in the seeding of the atmosphere by complex aerosol, a chemical composition of which can be expressed by the formula

5 $\text{AgI} \cdot \text{M}'\text{I} \cdot \text{M}_i'\text{O}_j\text{I}_k$. Here M' is alkali metal or NH_4 group, M'' is lead, copper or barium, or the mixture thereof, and i, j and k are small arbitrary numerals. This aerosol is produced by burning solid pyrotechnical mixture of a particular chemical composition. The threshold temperature of

10 aerosol is not lower than -3°C , and the nucleation effectiveness in the temperature range -6 to -15°C , being rather uniform, amounts to about 10^{14} active nuclei per gram of silver iodide.

The fabrication of this pyrotechnical mixture is rather

15 simple, involving only homogenisation and pressing powdered ingredients, with the option of wetting them by an organic solvent before or instead of pressing.

Description of the invention

The base of the new-developed method of atmospheric water precipitation is a solid pyrotechnical mixture containing

20 the following ingredients, or groups of ingredients, in the form of powders of particle diameter below $100\text{ }\mu\text{m}$:

- silver iodide
- group I of additives
- group II of additives
- 25 - oxidizer
- fuel/binder

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The group I of additives comprises alkali or ammonium iodides, iodates or periodates, individually or mixed.

5 The group II of additives comprises iodides, iodates or periodates of lead, copper or barium, or of barium chromate, or of mixtures thereof, individually or mixed.

The oxidizer is ammonium perchlorate, however, when the additives are iodates, periodates or chromates, they act as oxidizers too.

10 Fuel, which serves as the binder too, is an organic polymer from the group: poly-p-phenylene, phenolic resin, epoxide resin and shellac.

Examples

15 Example I. A mixture was made of 14% silver iodide, 25% sodium iodate, 4% barium chromate, 3% copper iodate, 14% poly-p-phenylene and 42% ammonium perchlorate. After homogenisation the mixture was formed into pellets by pressing.

20 Example II. A mixture made of 1.5% silver iodide, 20% potassium periodate, 5% barium iodate, 4% copper iodide, 4% lead iodide, 16% phenolic resin and 53.5% ammonium perchlorate was homogenized. The mixture was wetted by acetone and placed in air to solidify into a compact piece.

Example III. A mixture of 8% silver iodide, 23% potassium iodate, 3% lead iodate, 4% copper iodide, 15% poly-p-phenylene and 46% ammonium perchlorate was homogenized and pressed into pallets.

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Example IV. A mixture as in the example III, containing shellac instead of poly-p-phenylene was wetted by acetone after homogenization. Acetone evaporated when the mixture was placed in air while a solid mass of pyrotechnical mixture remained.

Example V. A mixture as in example III, containing phenolic resin and uncured epoxy resin in the weight ratio 1 : 1 instead of poly-p-phenylene was wetted by acetone, homogenized and placed in air. After acetone was evaporated and epoxide resin cured, a compact piece of the pyrotechnical mixture remained.

Having been ignited, each mixture described in the Example section burns uniformly, generating an active aerosol. The nucleation ability of aerosol was examined in an isothermal cloud chamber in the function of temperature. A measurable effectiveness was noted already at -3°C . At -6°C , $5 \cdot 10^{13}$ - $1 \cdot 10^{14}$ active nuclei per one gram of silver iodide was measured, while in the temperature range -6 to -15°C , the effectiveness was about $1 \cdot 10^{14}$ - $2 \cdot 10^{14}$ active nuclei per gram silver iodide. The aerosol is fast-acting, and precipitation of ice crystals in the cloud chamber completes within 2 minute only.

It is evident that the complex aerosols show a higher nucleation ability than the simple ones. This fact will be discussed in more detail.

For instance, aerosols AgI-alkali iodides, generated by burning solid pyrotechnical mixtures, as well as aerosols AgI-AgCl-NaCl, generated by burning liquid solutions, are considerable more effective than pure silver iodide aerosol.

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By comparing in addition above mentioned two- and three-component aerosols mutually, it can be noted that, in respect to the limit temperature of -8°C , the first ones are superior at higher, and the second ones at lower temperatures.

This invention shows that after addition to the first aerosol of a new component being iodide, oxyiodide or oxide of a heavier metal, its nucleation ability increases for about one order of magnitude. In addition, the superiority range of this aerosol, as compared to the aerosol AgI-AgCl-NaCl , extends to below -10°C .

A superior effectiveness of multicomponent aerosols over that of pure silver iodide is probably due to two following effects.

I. The presence of alkali halogenide makes the multicomponent aerosol hygroscopic. On that basis, the aerosol acts directly on the gas phase, sampling the water molecules and forming the droplets, which are iced by silver iodide. This nucleation mechanism is named condensation-freezing mechanism in the scientific literature. In contrary to that, pure silver iodide aerosol being rather hydrophobic, acts preferably by collisions with atmospheric water droplets (the contact-freezing nucleation mechanism) what makes its action considerably slower and less effective.

Having in mind that the additional components defined by this invention (iodides, oxyiodides and oxides of heavier metals) are essentially unhygroscopic, their favourable influence on the aerosol effectiveness cannot be ascribed to the hygroscopicity effects.

II. In the solid electrolyte electrochemistry it is known that the systems AgI-alkali iodides with the mole ratio about 4 : 1, belong to the group of superionic conductors. Their crystallographic structure is considered to be "averaged" one due to a high mobility of silver cations. This behaviour means probably an increased statistical weight of that crystallographic structure favoring the formation of ice crystal nuclei at its surface. From this point of view, an additional influence in favor of nucleation ability, realised by additives defined by this invention, could be ascribed to an additional increase of the statistical weight of that crystal structure favoring the ice nuclei formation.

THE FOLLOWING DESCRIPTION IS OF A PREFERRED EMBODIMENT BY WAY OF
EXAMPLE ONLY AND WITHOUT LIMITATION TO THE COMBINATION OF FEATURES
NECESSARY FOR CARRYING THE INVENTION INTO EFFECT.

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1. A multicomponent aerosol composition for promoting
atmospheric water precipitation by seeding moist
atmospheric air at a temperature below 0°C comprising a
compacted mixture of 14% by weight silver iodide, 25% by
weight sodium iodate, 3% by weight copper iodate, 4% by
weight barium chromate, 42% by weight ammonium perchlorate
and 14% by weight poly-p-phenylene.

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2. A multicomponent aerosol composition for promoting
atmospheric water precipitation by seeding moist
atmospheric air at a temperature below 0°C comprising a
compacted mixture of 1.5% by weight silver iodide, 20% by
weight potassium periodate, 5% by weight barium iodate, 4%
by weight copper iodide, 4% by weight lead iodide, 53.5%
by weight ammonium perchlorate, and 16% by weight phenolic
resin.

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3. A multicomponent aerosol composition for promoting
atmospheric water precipitation by seeding moist
atmospheric air at a temperature below 0°C comprising a
compacted mixture of 8% by weight silver iodide, 23% by
weight potassium iodate, 3% by weight lead iodate, 4% by
weight copper iodide, 46% by weight ammonium perchlorate,
and 15% by weight poly-p-phenylene.

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4. A method of atmospheric water precipitation
comprising seeding the moist atmosphere at a temperature
below 0°C by an aerosol generated by burning a pyrotechnic
mixture comprising a compacted mixture of 14% by weight
silver iodide, 25% by weight sodium iodate, 3% by weight
copper iodate, 4% by weight barium chromate, 42% by weight
ammonium perchlorate and 14% by weight poly-p-phenylene.

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5. A method of atmospheric water precipitation comprising seeding the moist atmosphere at a temperature below 0.degree. C. by an aerosol generated by burning a pyrotechnic mixture comprising a compacted mixture of 1.5% by weight silver iodide, 20% by weight potassium periodate, 5% by weight barium iodate, 4% by weight copper iodide, 4% by weight lead iodide, 53.5% by weight ammonium perchlorate, and 16% by weight phenolic resin.

6. A method of atmospheric water precipitation comprising seeding the moist atmosphere at a temperature below 0°C by an aerosol generated by burning a pyrotechnic mixture comprising a compacted mixture of 8% by weight silver iodide, 23% by weight potassium iodate, 3% by weight lead iodate, 4% by weight copper iodide, 46% by weight ammonium perchlorate, and 15% by weight poly-p-phenylene.