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PHOTOELECTRIC CONVERSION ELEMENT, MANUFACTURING METHOD OF THE SAME AND ELECTRONIC EQUIPMENT

Abstract

The present invention provides a photoelectric conversion element for use, for example, as a dye sensitized solar cell that has a wide range of choices of additives and moreover offers better characteristics than when 4-tert-butylpyridine is used as an additive.

In the photoelectric conversion element having a structure in which an electrolyte layer (7) is filled between a porous photoelectrode (3) formed above a transparent substrate (1) and a counter electrode (6), an additive having a pK_a falling within the range of $6.04 \leq pK_a \leq 7.3$ is added to the electrolyte layer (7), and/or the additive having a pK_a falling within the range of $6.04 \leq pK_a \leq 7.3$ is adsorbed to the surface of at least either the porous photoelectrode (3) or counter electrode (6) facing the electrolyte layer (7). A pyridine-based additive or an additive having a heterocycle is used as an additive. When the electrolyte layer (7) includes an electrolytic solution, a solvent having a molecular weight of 47.36 or more is used as the solvent of the

electrolytic solution. In the dye sensitized photoelectric conversion element, a photosensitizing dye is bound to the surface of the porous photoelectrode (3).

Claims

1. A photoelectric conversion element having a structure in which an electrolyte layer is filled between a porous photoelectrode and counter electrode, wherein

an additive having a pK_a falling within the range of $6.04 \leq pK_a \leq 7.3$ is added to the electrolyte layer, and/or wherein

the additive having a pK_a falling within the range of $6.04 \leq pK_a \leq 7.3$ is adsorbed to the surface of at least either the porous photoelectrode or counter electrode facing the electrolyte layer.

2. The photoelectric conversion element of claim 1, wherein

the additive is a pyridine-based additive or an additive having a heterocycle.

3. The photoelectric conversion element of claim 2, wherein

the additive comprises at least one selected from among a group made up of 2-aminopyridine, 4-methoxypyridine, 4-ethylpyridine, N-methylimidazole, 2,4-lutidine, 2,5-lutidine, 2,6-lutidine, 3,4-lutidine and 3,5-lutidine.

4. The photoelectric conversion element of claim 1, wherein

the electrolyte layer comprises an electrolytic solution, and wherein

the molecular weight of the solvent of the electrolytic solution is 47.36 or more.

5. The photoelectric conversion element of claim 4, wherein

the solvent is 3-methoxypropionitrile, methoxyacetonitrile or a mixture of acetonitrile and valeronitrile.

6. The photoelectric conversion element of claim 1 being:

a dye sensitized photoelectric conversion element in which a photosensitizing dye is bound to the porous photoelectrode.

7. (Amended) The photoelectric conversion element of claim 6, wherein

the dye is a polypyridine complex having a saturated hydrocarbon group whose carbon number is 6 or more.

8. (Amended) The photoelectric conversion element of claim 1, wherein

the porous photoelectrode comprises fine particles made of a semiconductor.

9. (Amended) The photoelectric conversion element

of claim 1, wherein

the electrolyte layer comprises an electrolytic solution, and wherein

the solvent of the electrolytic solution includes an ionic liquid having electron pair accepting functional groups and an organic solvent having electron pair donating functional groups.

10. (Amended) The photoelectric conversion element of claim 1, wherein

the porous photoelectrode comprises fine particles, each having a metallic core and a metal oxide shell wrapped around the core.

11. (Amended) A manufacturing method of a photoelectric conversion element comprising a step of:

adding an additive having a pK_a falling within the range of $6.04 \leq pK_a \leq 7.3$ to an electrolyte layer filled between a porous photoelectrode and counter electrode; and/or a step of:

causing the additive having a pK_a falling within the range of $6.04 \leq pK_a \leq 7.3$ to be adsorbed to the surface of at least either the porous photoelectrode or counter electrode facing the electrolyte layer.

12. (Amended) The manufacturing method of a photoelectric conversion element of claim 11, wherein

the additive is a pyridine-based additive or an additive having a heterocycle.

13. (Amended) The manufacturing method of a photoelectric conversion element of claim 12, wherein

the additive comprises at least one selected from among a group made up of 2-aminopyridine, 4-methoxypyridine, 4-ethylpyridine, N-methylimidazole, 2,4-lutidine, 2,5-lutidine, 2,6-lutidine, 3,4-lutidine and 3,5-lutidine.

14. (Amended) The manufacturing method of a photoelectric conversion element of claim 11, wherein

when a structure is formed in which the electrolyte layer made of an electrolytic solution is filled between the porous photoelectrode and counter electrode, a solvent having a molecular weight of 47.36 or more is contained in the electrolytic solution.

15. (Amended) The manufacturing method of a photoelectric conversion element of claim 14, wherein

the solvent is 3-methoxypropionitrile, methoxyacetonitrile or a mixture of acetonitrile and valeronitrile.

16. (Amended) The manufacturing method of a photoelectric conversion element of claim 11 further comprising

a step of binding a photosensitizing dye to the porous photoelectrode.

17. (Amended) The manufacturing method of a photoelectric conversion element of claim 11, wherein

the porous photoelectrode comprises

fine particles made of a semiconductor.

18. (Amended) The manufacturing method of a photoelectric conversion element of claim 11, wherein

when a structure is formed in which the electrolyte layer made of an electrolytic solution is filled between the porous photoelectrode and counter electrode, an ionic liquid having electron pair accepting functional groups and an organic solvent having electron pair donating functional groups are contained in the electrolytic solution.

19. (Amended) The manufacturing method of a photoelectric conversion element of claim 11, wherein

the porous photoelectrode comprises fine particles, each having a metallic core and a metal oxide shell wrapped around the core.

20. (New) Electronic equipment comprising at least:

a photoelectric conversion element, the photoelectric conversion element having a structure in which an electrolyte layer is filled between a porous photoelectrode and counter electrode, wherein

an additive having a pK_a falling within the range of $6.04 \leq pK_a \leq 7.3$ is added to the electrolyte layer, and/or wherein

the additive having a pK_a falling within the range of $6.04 \leq pK_a \leq 7.3$ is adsorbed to the surface of at least either the porous photoelectrode or counter electrode facing the electrolyte layer.

Dated this 10/1/2012

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FIG. 1

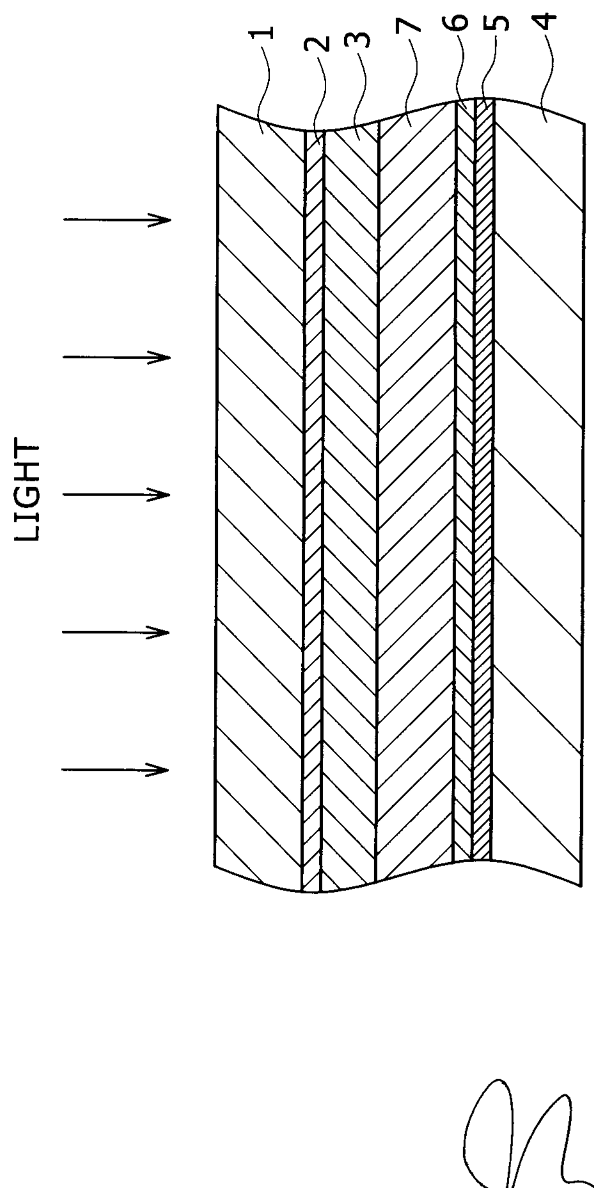

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FIG. 2

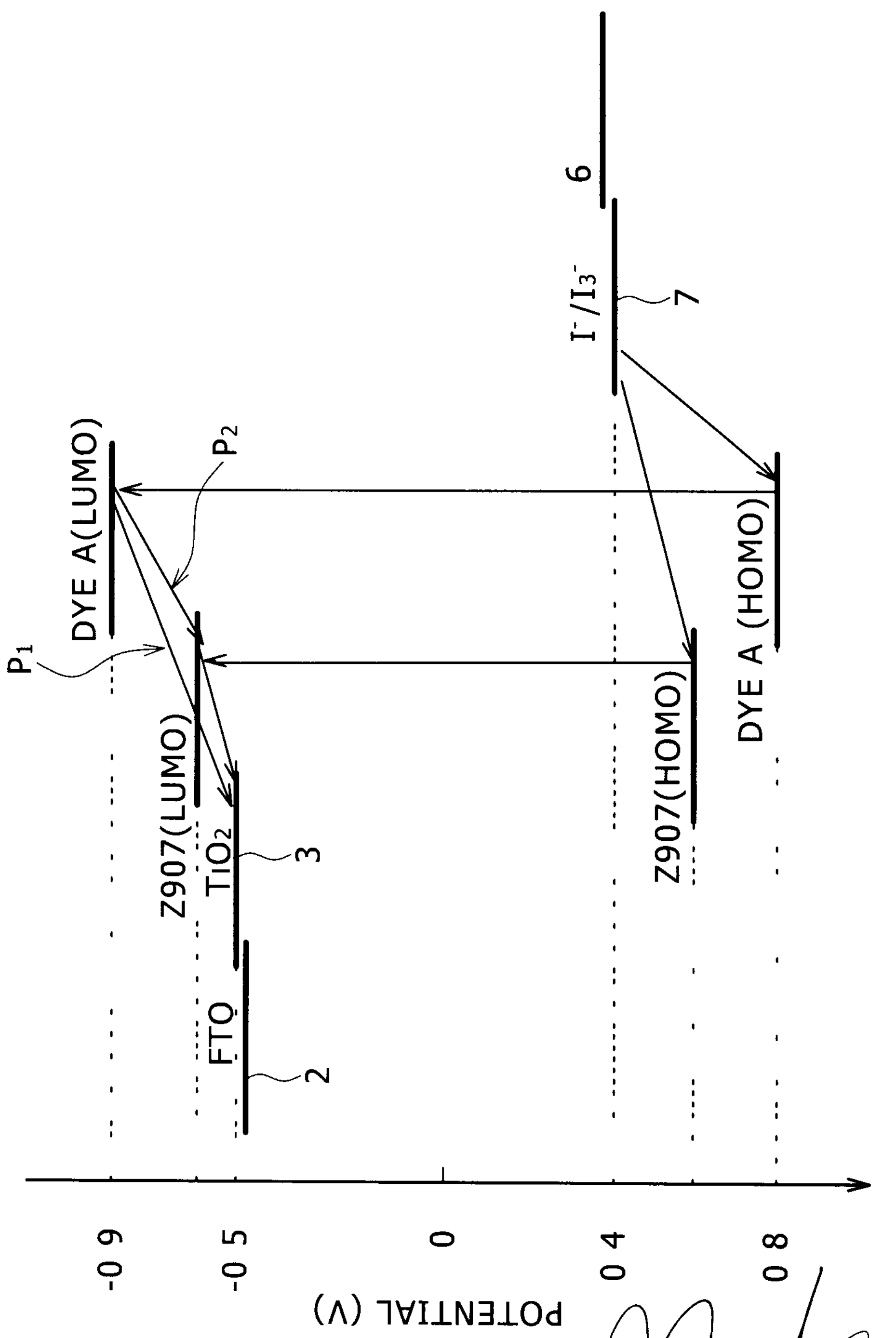

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FIG.3

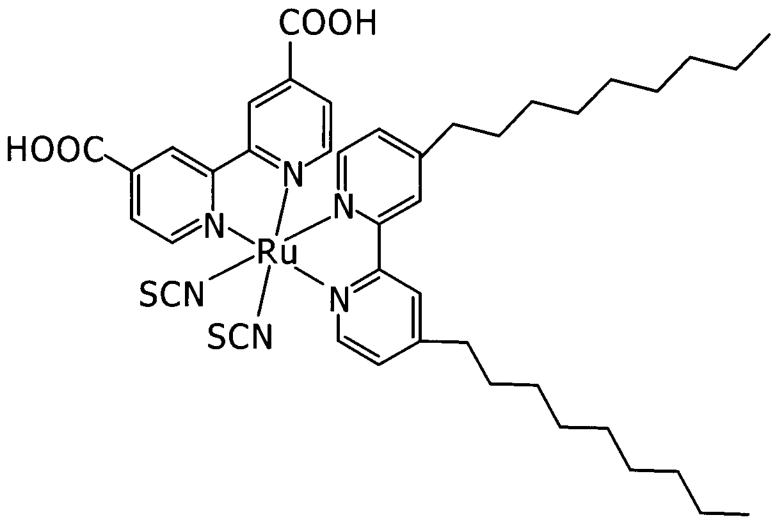

FIG.4

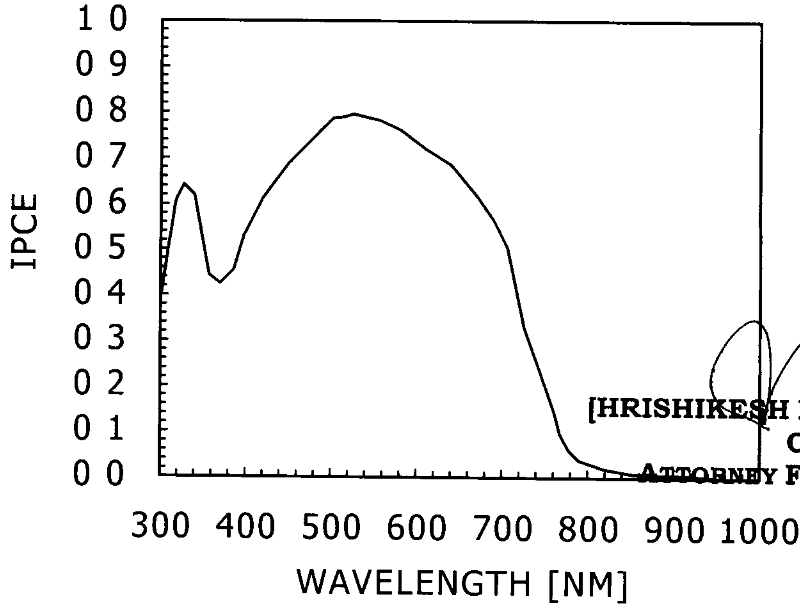

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FIG.5

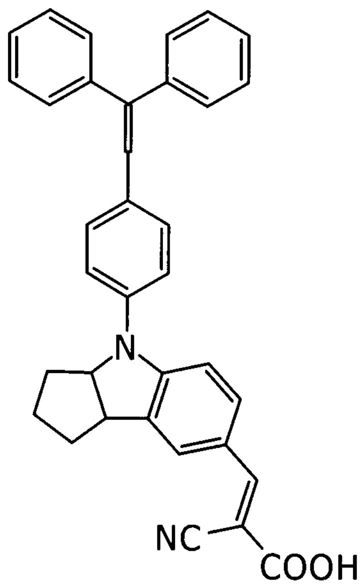

FIG.6

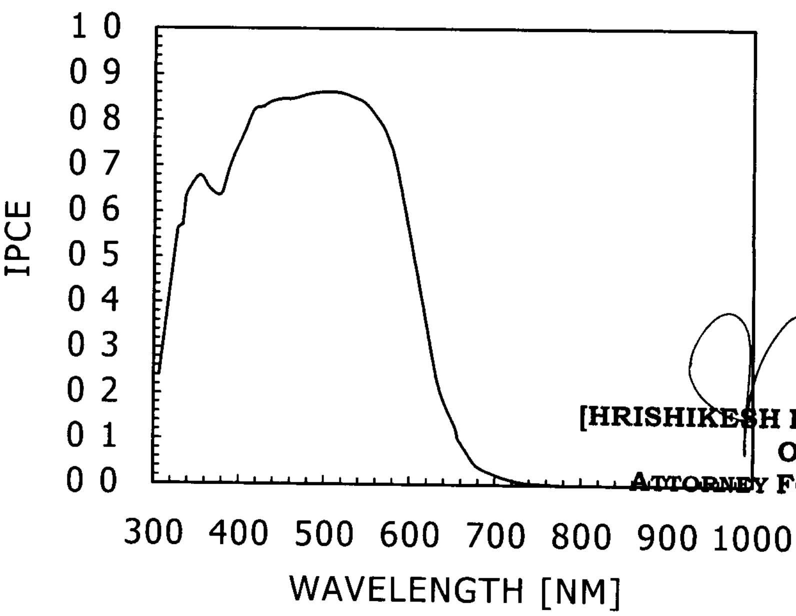

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FIG.7

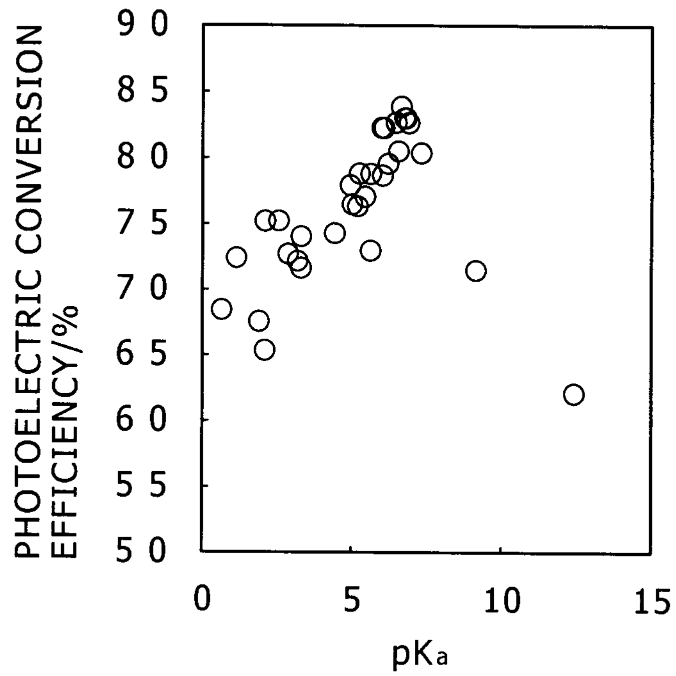

FIG.8

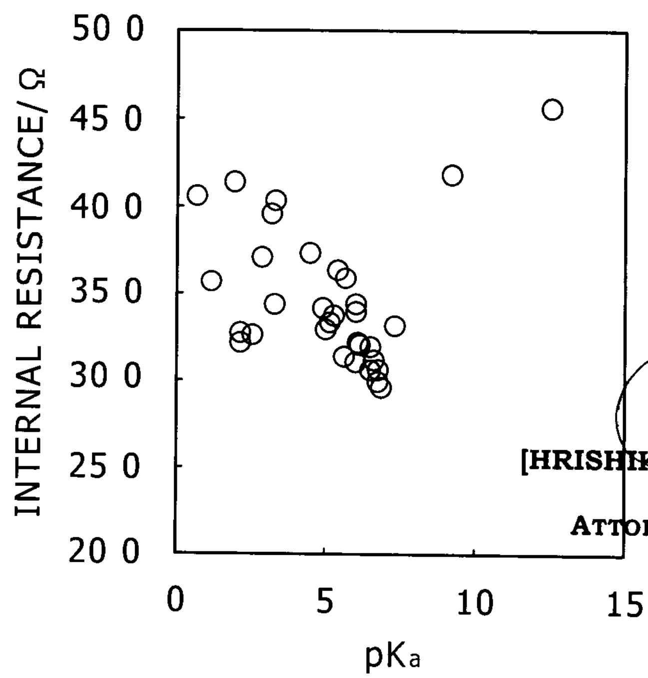

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FIG.9

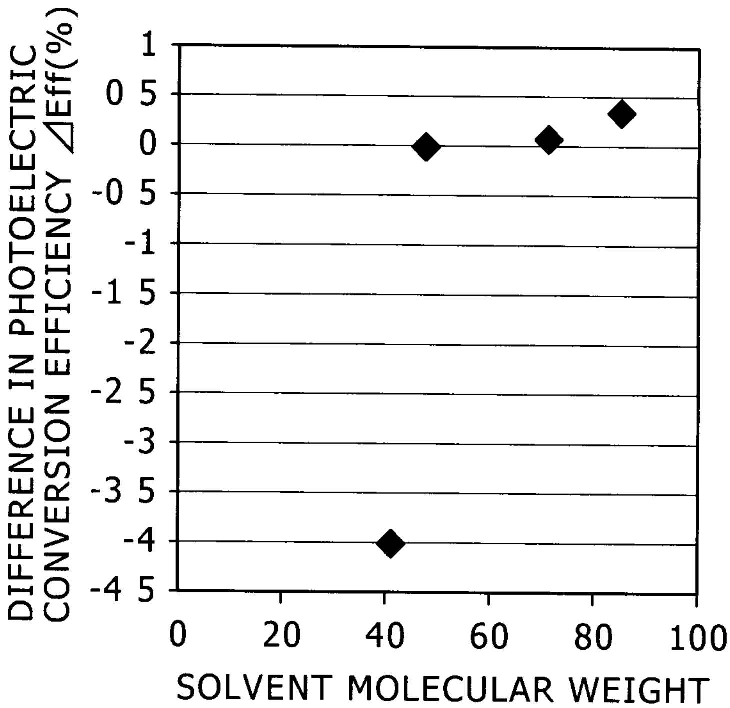

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FIG.10

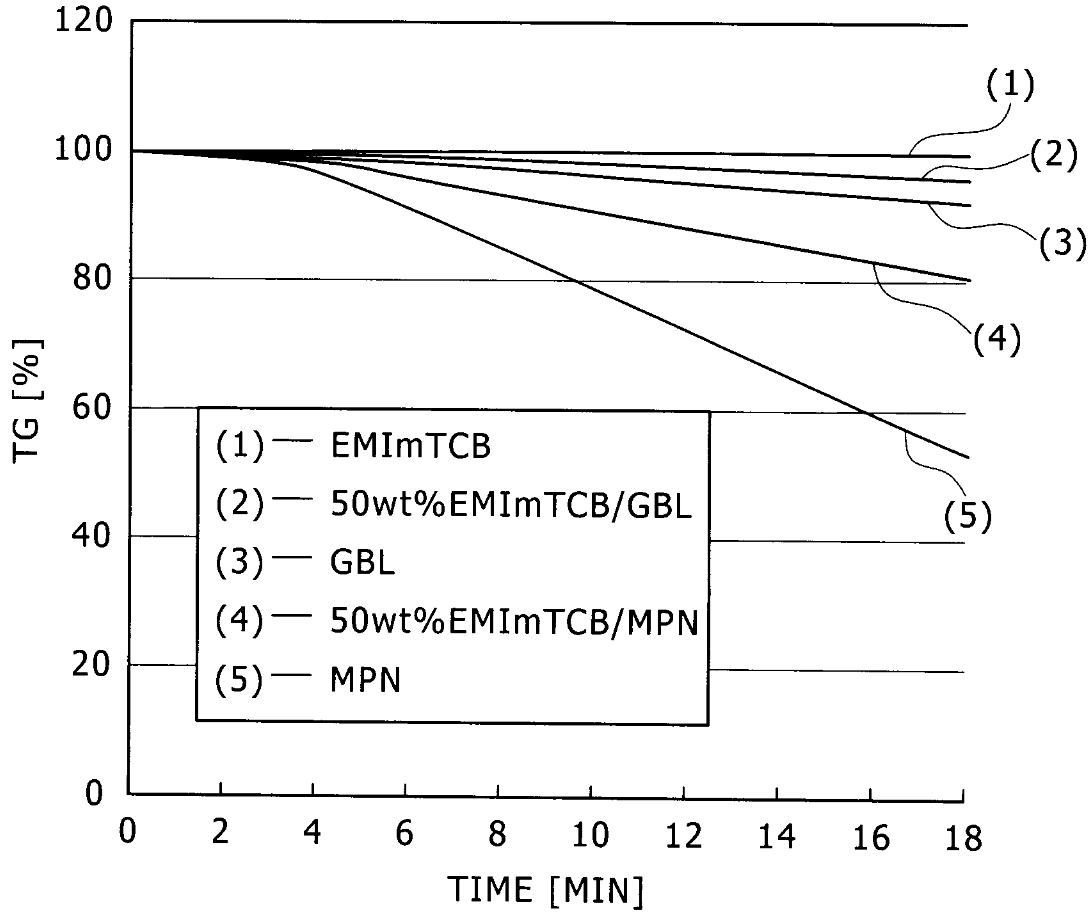

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FIG.11

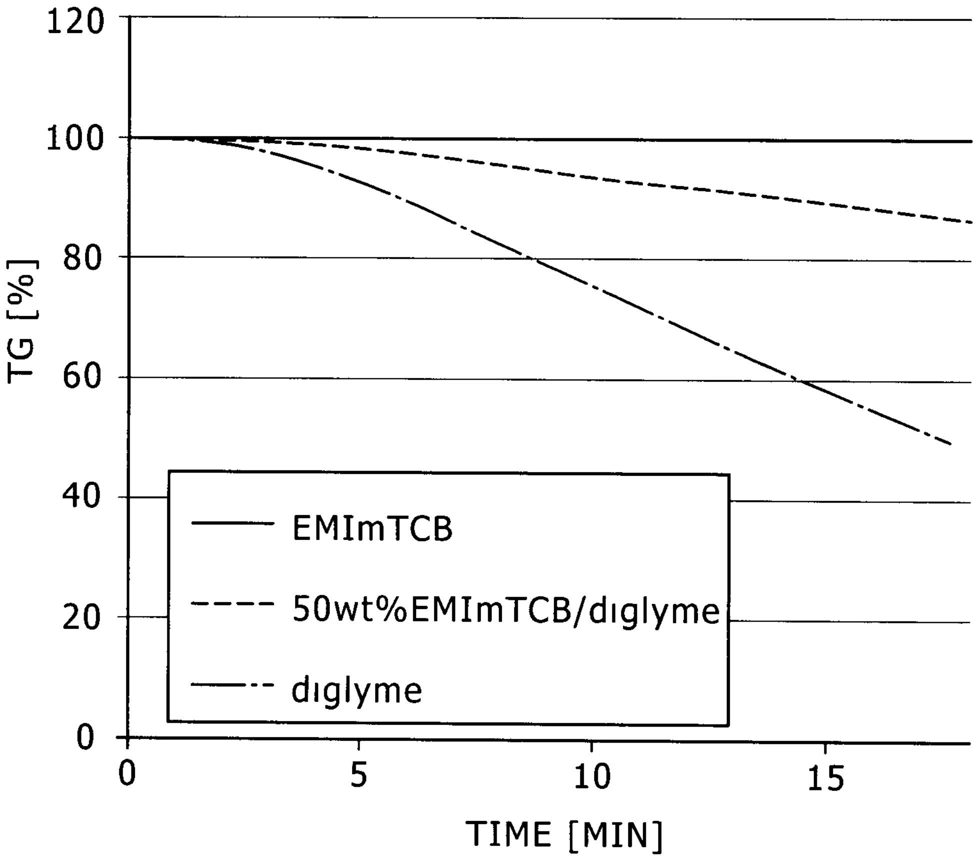

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FIG.12

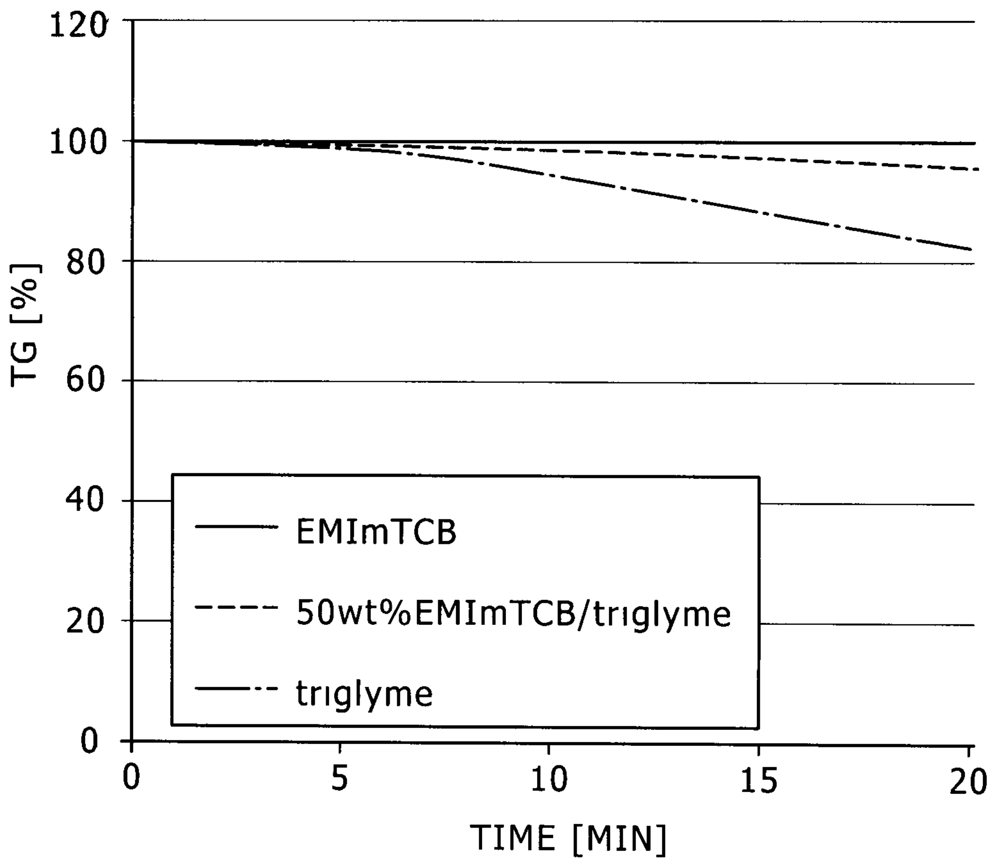

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FIG.13

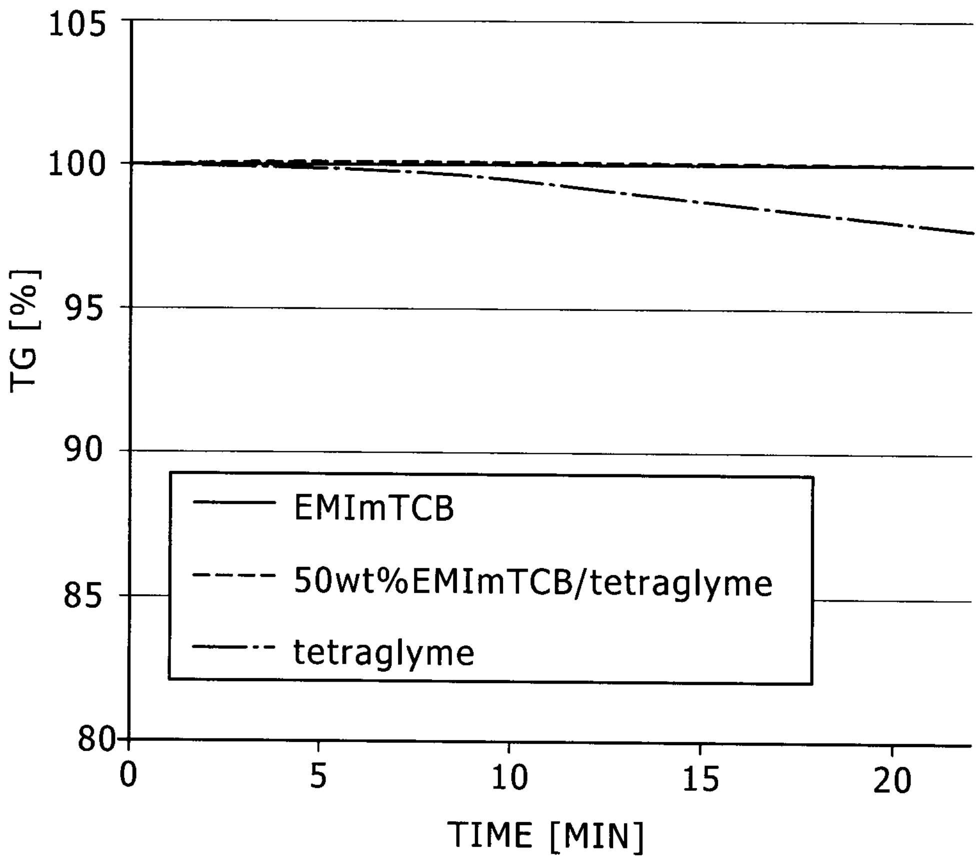

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FIG.14

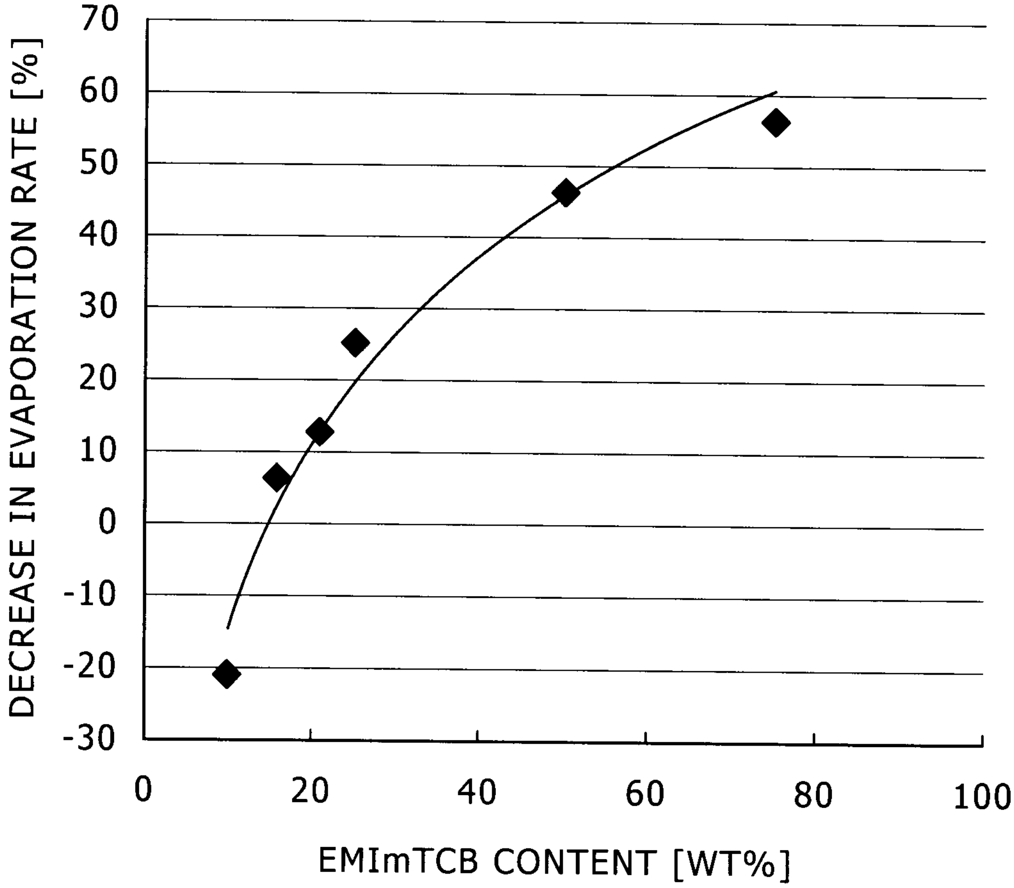

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FIG.15

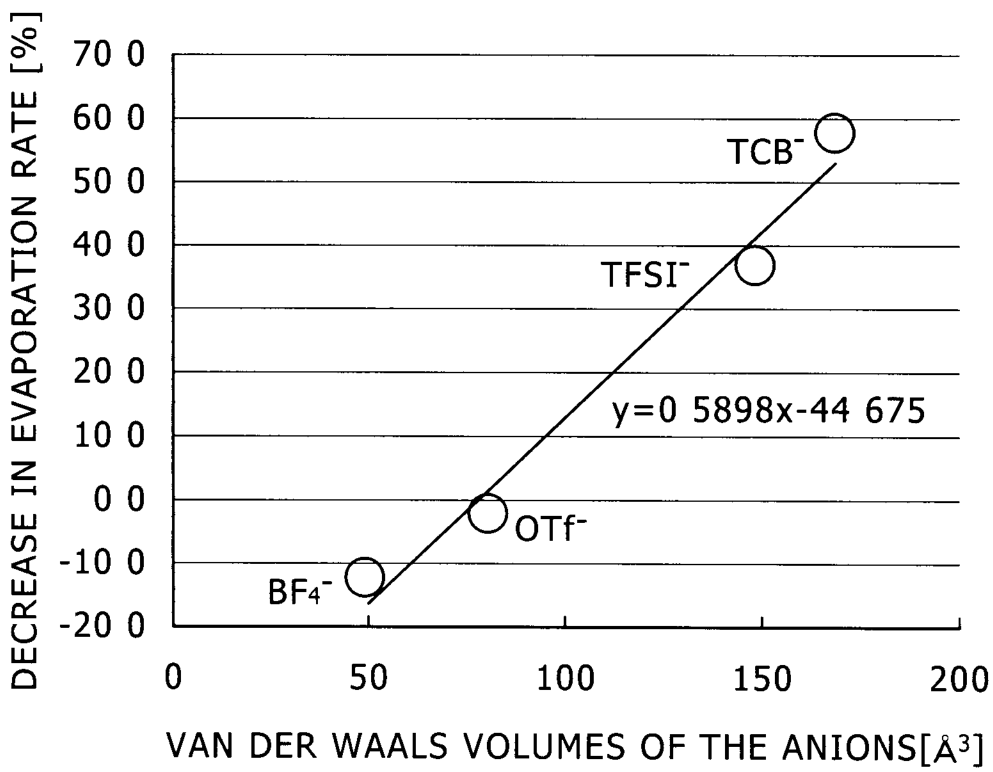

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FIG.16

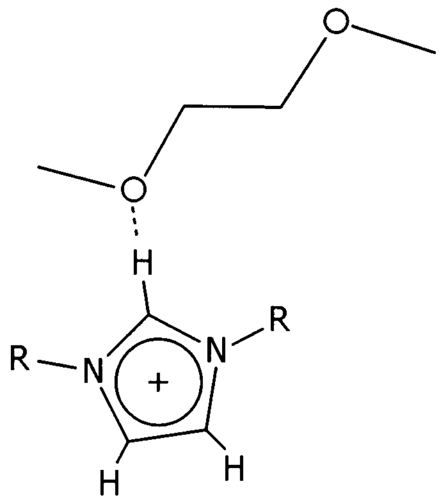

FIG.17

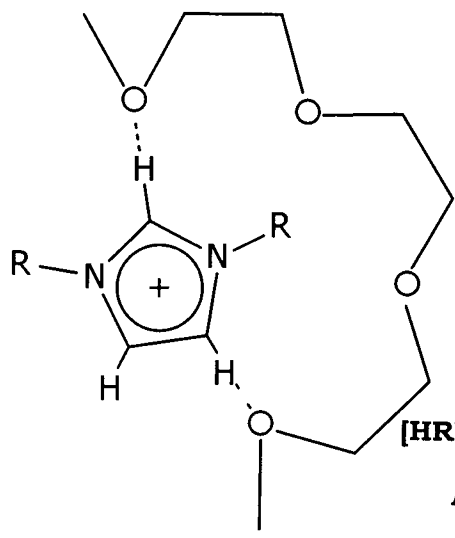

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FIG.18

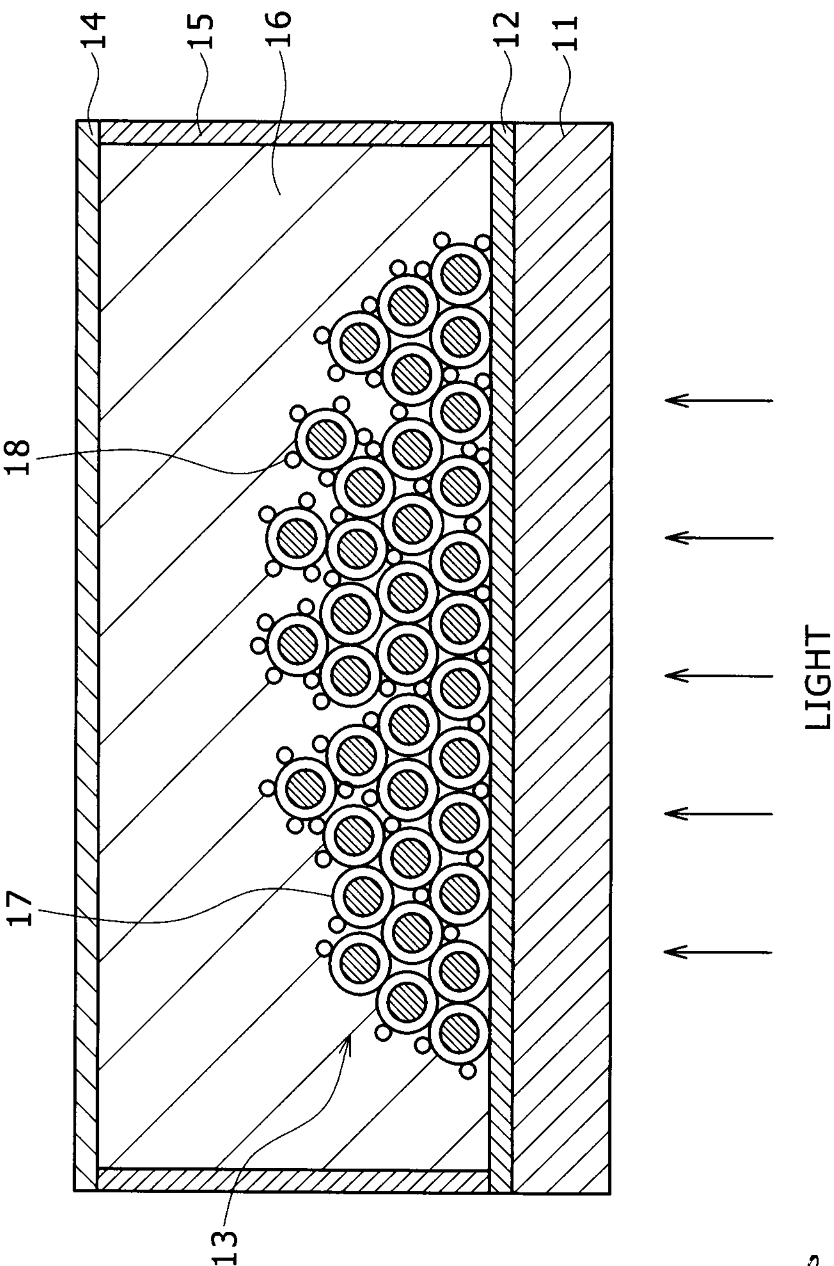

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FIG.19

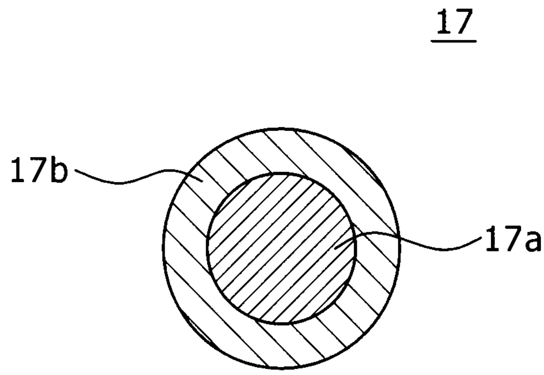

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FIG.20

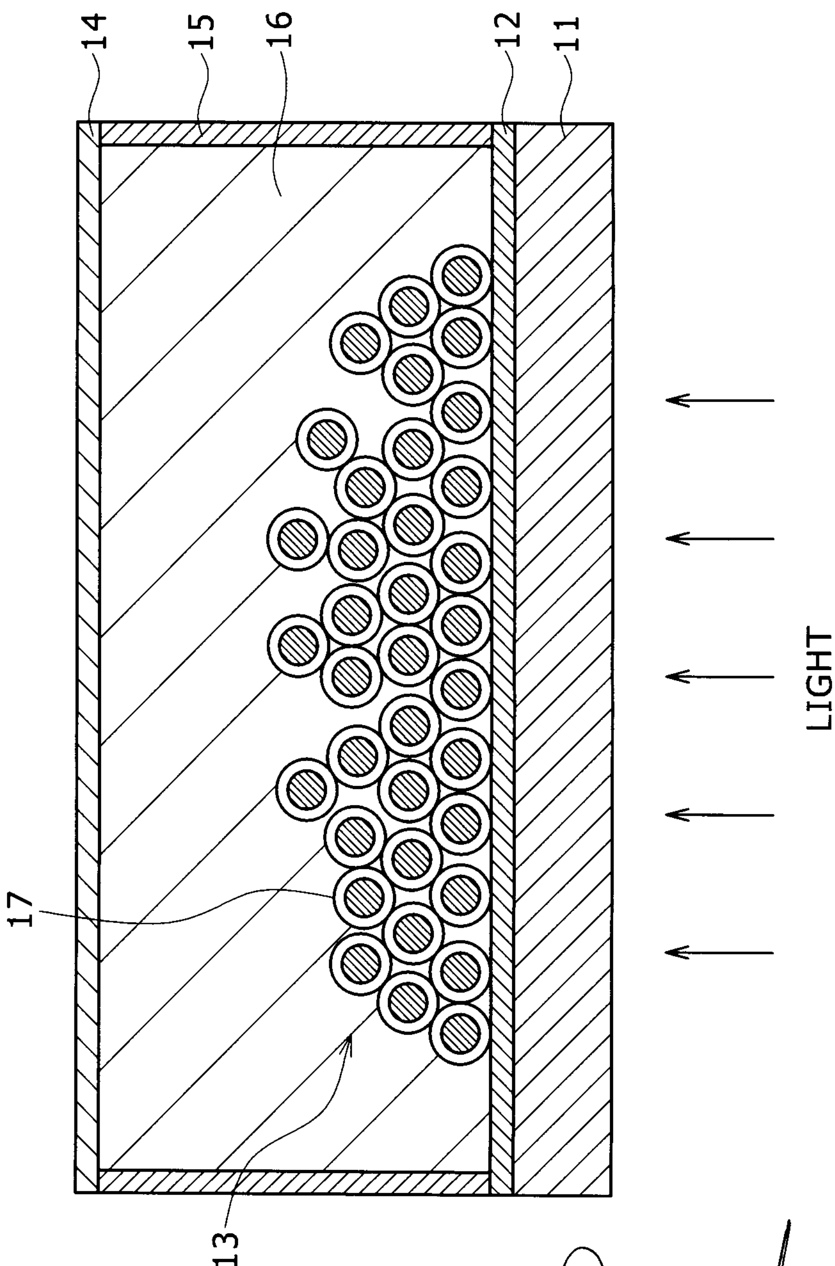

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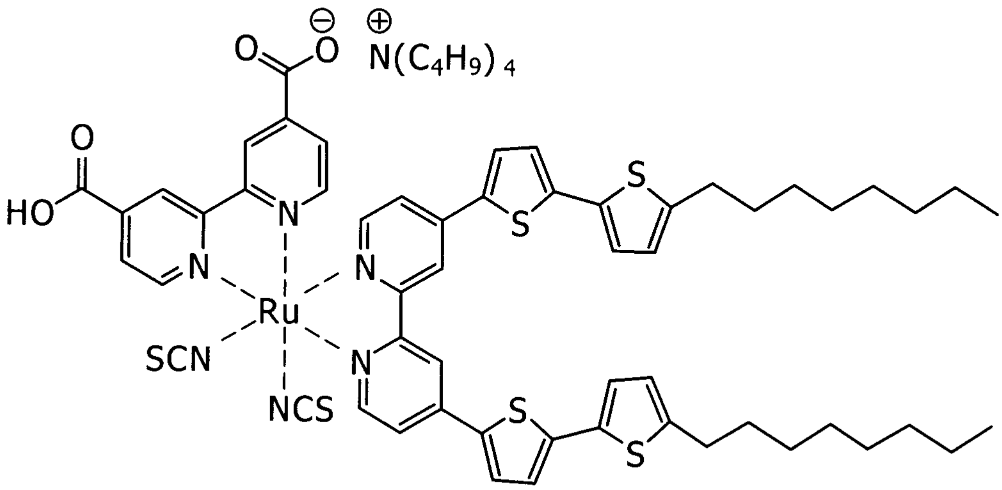
FIG.21



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Technical Field

The present invention relates to a photoelectric conversion element, manufacturing method of the same and electronic equipment, and relates, for example, to a photoelectric conversion element suitable for use as a dye sensitized solar cell, a manufacturing method of the same and electronic equipment using the same.

Background Art

A solar cell, i.e., a photoelectric conversion element adapted to convert sunlight into electric energy, uses sunlight as a source of energy, thus making its impact on the global environment extremely small and holding promise for even more widespread use.

Crystalline silicon-based solar cells using monocrystalline and polycrystalline silicons and amorphous silicon-based solar cells have been primarily used as solar cells.

On the other hand, a dye sensitized solar cell proposed by Gratzel et al. in 1991 offers high photoelectric conversion efficiency and moreover can be manufactured at low cost because this solar cell does not require any large-scale manufacturing system as do the conventional silicon-based solar cells, thus drawing attention (refer, for example, to Non-Patent Document 1).

In general, this dye sensitized solar cell has a porous photoelectrode and a counter electrode opposed to each other. The porous photoelectrode is made of titanium oxide to which a photosensitizing dye is bound. The counter electrode is made, for example, of platinum. An electrolyte layer made of an electrolytic solution is filled between the porous photoelectrode and counter electrode. An electrolyte containing redox species such as iodine or iodide ion dissolved in a solvent is often used as an electrolytic solution. An additive is commonly added to this electrolytic solution to prevent reverse electron transfer from the porous photoelectrode to the electrolyte layer. Four-tert-butylpyridine (TBP) is the best known additive.

Prior Art Documents

Non-Patent Documents

Non-Patent Document 1: Nature, 353, p.737 - 740, 1991

Non-Patent Document 2: Inorg. Chem. 1996, 35, 1168 - 1178

Non-Patent Document 3: J. Chem. Phys. 124, 184902(2006)

Summary of Invention

However, the types of additives added to the electrolytic solution of the dye sensitized solar cell are limited, making the range of choices extremely small and resulting in low degree of freedom in designing the electrolytic solution.

In light of the foregoing, a problem to be solved by the present invention is to provide a photoelectric conversion element for use, for example, as a dye sensitized solar cell that has a wide range of choices of additives and moreover offers better characteristics than when 4-tert-butylpyridine is used as an additive.

Another problem to be solved by the present invention is to provide a manufacturing method of a photoelectric conversion element that can manufacture the excellent photoelectric conversion element as described above.

Still another problem to be solved by the present invention is to provide high performance electronic equipment using the excellent photoelectric conversion element as described above.

The present inventor et al. diligently made experimental and theoretical studies to solve the above problems. As a result, it was discovered that there are many additives that offer better characteristics than 4-

tert-butylpyridine, an additive commonly added to the electrolyte layer. More specifically, we devised the present invention after having reached a conclusion that an additive having a pK_a of 6.04 or more and 7.03 or less, i.e., a pK_a falling within the range of $6.04 \leq pK_a \leq 7.3$, offers better characteristics than 4-tert-butylpyridine.

That is, in order to solve the above problems, the present invention is a photoelectric conversion element that has a structure in which an electrolyte layer is filled between a porous photoelectrode and counter electrode. An additive having a pK_a falling within the range of $6.04 \leq pK_a \leq 7.3$ is added to the electrolyte layer, and/or the additive having a pK_a falling within the range of $6.04 \leq pK_a \leq 7.3$ is adsorbed to the surface of at least either the porous photoelectrode or counter electrode facing the electrolyte layer.

Further, the present invention is a manufacturing method of a photoelectric conversion element that includes a step of adding an additive having a pK_a falling within the range of $6.04 \leq pK_a \leq 7.3$ to an electrolyte layer filled between a porous photoelectrode and counter electrode, and/or a step of causing the additive having a pK_a falling within the range of $6.04 \leq pK_a \leq 7.3$ to be adsorbed to the surface of at least either the porous