

- a) a modified support having an even surface, in which modification means the application of ions or ionisable compounds of the same charge over the entire area, and
- b) one or more layers made of organic materials which in each layer contain ions of the same charge, the ions of the first layer having the opposite charge of the modified support and in the case of several layers each further layer having again the opposite charge of the previous layer.

The invention furthermore relates to a process for the preparation of layer elements applied to supports, characterised in that

- i) a support having a flat surface is modified such that it carries ions or ionisable compounds of the same charge over the entire area, and
- ii) one or more layers made of organic materials, which in each layer have ions of the same charge, are applied from a solution of such organic materials to the modified support, the organic material for the first layer having ions of the opposite charge relative to the charge of the ions of the modified support and, in the case of multiple layers, alternating further layers containing ions of the opposite charge in each case relative to the previous one are applied in the same manner as the first layer.

BRIEF DESCRIPTION OF THE DRAWINGS

The attached figures (FIG. 1A, 1B and 2-12) illustrate exemplary embodiments in addition to the examples.

DETAILED DESCRIPTION OF THE INVENTION

Multi-layer systems of the type described comprise at least two materials having ionic groups of opposite charges. Thus, the simplest layer sequence is of the ABABAB . . . type. However, the functionality of the layers can be selectively increased by using more than 2 materials. for example ABCBABA BCB . . . or ABCD-CBADCBAC . . . , in which A and C and B and D carry the same charge. The layer sequence is a consequence of the selection of the dipping bath used in each case for applying the individual layers.

The process according to the invention allows large-area highly ordered multi-layered layer elements on supports to be produced.

Suitable supports for the layer elements according to the invention are those having a surface which is flat and accessible to solvents, for example flat, cylindrical, conical, spherical or other supports of uniform shape, which thus also include interior surfaces of bottles, tubings, and the like; supports having a flat surface are preferred. For various optical or electrical areas of application, the supports can be transparent, impermeable or reflecting as well as electrically conducting, semi-conducting or insulating. The chemical nature of these supports can be inorganic or organic. Examples of inorganic support materials are metals, semi-conductor materials, glasses or ceramic materials, such as gold, platinum, nickel, palladium, aluminium, chromium, steel and other metals, germanium, gallium arsenide, silicon and other semi-conductor materials, glasses of a wide range of chemical composition, quartz glass, further glasses, and porcelain and further mixed oxides, which are understood to mean ceramic materials. Further inorganic substances which are suitable as supports are, for example, graphite, zinc selenide, mica, silicon

dioxide, lithium niobate and further supports, if desired in the form of inorganic single crystals, such as are known to one skilled in LB technology.

Organic materials for the supports of the layer elements according to the invention are predominantly polymer materials, due to the dimensional stability and resistance to solvents. Examples which may be mentioned are: polyesters, such as polyethylene terephthalate, polybutylene terephthalate and others, polyvinyl chloride, polyvinylidene fluoride, polytetrafluoroethylene, polycarbonate, polyamide, poly(meth)acrylate, polystyrene, polyethylene or ethylene/vinyl acetate copolymer. Organic supports of this type are also known to one skilled in LB technology.

The chemical nature of the support material plays a minor role, so that the above enumerations are only by way of example and are not exhaustive.

The supports to be used according to the invention have charged or ionisable surfaces or their surfaces are modified such that they are covered over the entire area with ions or ionisable compounds of the same charge. This application over the entire area can be a first monomolecular layer which is solidly attached to the support. However, the application of ions or ionisable compounds over the entire area can also be effected by a chemical reaction on the support itself, in which the surface is densely covered with ions or ionisable groups of the same charge to the extent of forming a monomolecular layer. Such a modification is known to one skilled in the art and working in the area of multi-layered thin films. Examples of these are self-assembly monolayers, for example comprising an α,ω -dithiol, cysteamine, amino-containing thiols and other thiols containing a further ionic or ionisable group, on metals, such as gold, silver, cadmium and others. In this case, the thiol group is solidly bound to the metallic surface and the second thiol group, a carboxyl group, an amino group or another ionic or ionisable group forms the ionic modification of the metallic support to be used. A further important example is silanation of the surface with silanes containing alkoxy groups, which additionally contain a further ionic or ionisable group. This silanation is possible with all silicon-containing supports in a manner known to one skilled in the art. The ionic or ionisable group can be, for example, a sulphur group or an ionisable amino group. A still further example relates to the chemical modification of polymeric organic supports (polymer-analogous reaction). Thus, for example, polyethylene can be provided on the surface with carboxyl groups by means of oxidising agents, such as chromic acid. (Meth)acrylate or (meth)acrylamides can also be provided on the surface with carboxyl groups by means of hydrolysis. Sulphonation of polystyrene resins on the surface also leads to a modification utilisable according to the invention. The last-mentioned modified polymers can also be called flat ion exchangers. Furthermore, it is known to one skilled in the art that instead of anionic groups (carboxyl groups, sulpho groups) cationic groups, such as amino groups, can also be obtained by chloromethylation, followed by the introduction of an amino group. Reactions of this type are known as polymer-analogous reactions.

Furthermore, freshly split mica may be mentioned, on which cationic compounds can be adsorbed directly. Furthermore, on glass or quartz, it is also possible to adsorb cationic compounds, such as polyethyleneimine, after short dipping into sodium hydroxide solution.