LAYER-BY-LAYER COATING APPARATUS AND METHOD

TECHNICAL FIELD

The disclosure relates to an apparatus for layer-by-layer coating as well as methods of layer-by-layer coating.

BACKGROUND

Layer-by-layer (sometimes known as LBL) coating is known in the art, and was traditionally performed by a dip-coating technique wherein a substrate was dipped in a polycation solution to deposit a monolayer of polycation. The substrate was removed from the polycation solution, rinsed to remove excess polycation, dipped into a polyanion solution to deposit a monolayer of polyanion, removed from the polyanion solution, and finally rinsed again to remove excess polyanion. The result of that process was a bilayer deposited on a surface of the substrate. The process could be repeated to obtain the desired number of bilayers.

A variety of substances have been used for the various monolayers of the LBL bilayer. Typically, the two monolayers are chosen so that each of the monolayers binds or adheres only to the other monolayer (and, in the case of the first deposited monolayer, to the substrate) but not to itself.

SUMMARY

An apparatus as disclosed herein can comprise a first roller for moving a belt, a second roller for moving a belt, a belt tensioned around the first roller and the second roller, and a deposition station positioned to face the belt, the deposition station comprising: (1) a first depositing element for affixing a monolayer of a first self-limiting monolayer forming material to the belt, (2) a rinsing element, and (3) a second depositing element for affixing a monolayer a second self-limiting monolayer forming material to the belt. The apparatus can also include a directional gas curtain producing element and positioned downstream from the deposition station to provide a gas curtain blowing on the belt in an upstream direction. In one aspect, there is provided an apparatus comprising a first roller for moving a belt; a second roller for moving a belt; a belt tensioned around the first roller and the second roller; a deposition station positioned to face a portion of the belt, wherein the portion of the belt is within 5 degrees of parallel to the ground, the deposition station comprising a first depositing element for affixing a monolayer of a first self-limiting monolayer forming material to the belt, a rinsing element, and a second depositing element for affixing a monolayer a second self-limiting monolayer forming material to the belt; and a directional gas curtain producing element and positioned downstream from the first depositing element to provide a gas curtain blowing on the belt in an upstream direction.

Methods of applying coatings, for example, using said apparatus, are also disclosed. In another aspect, there is provided a method of making a layer-by-layer coating on a substrate, the method comprising (a) tensioning a substrate in the form of a belt around a first roller and a second roller such that the belt faces a deposition station, the deposition station comprising a first depositing element for affixing at least a monolayer of a first self-limiting monolayer forming material to the belt, (b) moving the belt around the first roller and the second roller for a first revolution while engaging the first depositing element to apply a first liquid comprising a first self-limiting monolayer forming material on the belt; (c) engaging a directional gas curtain producing element that is positioned downstream from the deposition station to provide a gas curtain that simultaneously meters liquid from the belt and dries the belt, wherein the deposition station further comprises a rinsing element positioned downstream of the first depositing element, and a second depositing element positioned downstream from the rinsing element for affixing a monolayer of a second self-limiting monolayer forming material to the belt; and wherein the method further comprises the steps of (d) engaging the rinsing element; and (e) engaging the second deposition element to affix at least a monolayer of a second self-limiting monolayer forming material on the belt, wherein the deposition station is positioned to face a portion of the belt, and the portion of the belt is within 5 degrees of parallel to the ground.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 is a schematic of an apparatus as described herein;

Figure 2 is a schematic of another apparatus as described herein; and

Figure 3 is a graph of reflectance vs. wavelength.

What is claimed is:

1. An apparatus comprising

a first roller for moving a belt;

a second roller for moving a belt;

a belt tensioned around the first roller and the second roller;

a deposition station positioned to face a portion of the belt, wherein the portion of the belt is within 5 degrees of parallel to the ground, the deposition station comprising

a first depositing element for affixing a monolayer of a first self-limiting monolayer forming material to the belt,

a rinsing element, and

a second depositing element for affixing a monolayer a second self-limiting monolayer forming material to the belt; and

a directional gas curtain producing element and positioned downstream from the first depositing element to provide a gas curtain blowing on the belt in an upstream direction.

2. The apparatus of claim 1, further comprising a first backing element that is positioned such that at least a portion of the belt is interposed between the backing element and the directional gas curtain providing element.

3. The apparatus of any of the preceding claims, further comprising a second backing element positioned such at least a portion of the belt is interposed between the second backing element and the deposition station.

4. The apparatus of any of the preceding claims, wherein at least one of the first self-limiting monolayer forming material depositing element and the second self-limiting monolayer forming material depositing element is a sprayer.

5. The apparatus of any of the preceding claims, wherein the directional gas curtain producing element produces a directional gas curtain having a pressure sufficient to remove liquid, cationic material, or anionic material that is not affixed to the belt.

6. The apparatus of any of the preceding claims, wherein the apparatus is capable of affixing a monolayer of cationic material or anionic material to the belt while the belt is moving at a speed of at least 0.25 m/s.

7. The apparatus of any preceding claim, wherein the belt is an endless belt.

8. The apparatus of any preceding claim, wherein

the first self-limiting monolayer forming material is one and only one of a cationic material or an anionic material; and

the second self-limiting monolayer forming material is one and only one of a cationic material or an anionic material;

with the proviso that one and only one of the first self-limiting monolayer forming material and the second self-limiting monolayer forming material is a cationic material and the other is an anionic material.

9. The apparatus of any of the preceding claims, wherein the apparatus comprises at least 5 depositing elements.

10. A method of making a layer-by-layer coating on a substrate, the method comprising

(a) tensioning a substrate in the form of a belt around a first roller and a second roller such that the belt faces a deposition station,

the deposition station comprising

a first depositing element for

affixing at least a monolayer of a first self-limiting monolayer forming material to the belt,

(b) moving the belt around the first roller and the second roller for a first revolution while engaging the first depositing element to apply a first liquid comprising a first self-limiting monolayer forming material on the belt;

(c) engaging a directional gas curtain producing element that is positioned downstream from the deposition station to provide a gas curtain that simultaneously meters liquid from the belt and dries the belt,

wherein the deposition station further comprises

a rinsing element positioned downstream of the first depositing element, and

a second depositing element positioned downstream from the rinsing element for affixing a monolayer of a second self-limiting monolayer forming material to the belt; and wherein

the method further comprises the steps of

(d) engaging the rinsing element; and

(e) engaging the second deposition element to affix at least a monolayer of a second self-limiting monolayer forming material on the belt,

wherein the deposition station is positioned to face a portion of the belt, and the portion of the belt is within 5 degrees of parallel to the ground.

11. The method of claim 10, wherein the belt does not stop moving until at least one of a pre-determined number of monolayers are deposited, a pre-determined amount of time passes, a pre-determined thickness is achieved, or a pre-determined optical, chemical, or physical property is achieved.

12. The method of claim 10, wherein the apparatus contains at least 5 deposition stations.

13. The method of claim 12, wherein at each of steps (a) through (e) is repeated, in order, at least one additional time.

14. The method of any of claims 10-13, wherein

the first self-limiting monolayer forming material is one and only one of a cationic material or an anionic material; and

the second self-limiting monolayer forming material is one and only one of a cationic material or an anionic material;

with the proviso that one and only one of the first self-limiting monolayer forming material and the second self-limiting monolayer forming material is a cationic material and the other is an anionic material.