with an upper horizontal heat weld disposed above a tapered crimp with a gap that defines an integral drinking solubility spout when the tear strip above the perforated line is removed from the individual beverage receptacle units. However, this packaging is not environmental friendly.

[009] United States Patent No. 5,756,194 discloses water-resistant starch products useful in the food industry that comprise an inner core of gelatinized starch, an intermediate layer of natural resin and an outer layer of water resistant biodegradable polyester. The gelatinized starch can be made water-resistant by coating with biodegradable polyesters such as poly(beta-hydroxybutyrate-co-valerate) (PHBV), poly(lactic acid) (PLA), and poly(epsilon-caprolactone) (PCL). Adherence of the two dissimilar materials is achieved through the use of an intervening layer of a resinous material such as shellac or rosin which possesses a solubility parameter (hydrophobicity) intermediate to that of the starch and the polyesters. Coating is achieved by spraying an alcoholic solution of the shellac or rosin onto the starch-based article and subsequently coating with a solution of the polyester in an appropriate solvent. However, these products are not optimally designed for allowing a user to carry them easily while being in a physical activity. In addition, they are not designed to provide different liquid volumes that can be consumed according to instant needs.

[0010] Therefore, there is a need in the art for a biodegradable sheet that is physically strong, though flexible, and further, has low gas permeability, a high light transmittance, a long shelf life and low haze. Such a biodegradable sheet could be used as a long term receptacle.

SUMMARY

[0011] The present disclosure is based in part on the discovery that a single layered or multilayered biodegradable sheet comprising PCL or PHA in combination with one or more hydrophobic biodegradable polymers exhibits surprising properties, including reduced water vapor transmission rate (WVTR) and oxygen transmission rate (OTR) and improved heat sealing, while maintaining the mechanistic features of flexible sheets. These properties cannot be explained by the properties of the individual polymers making up the sheet.

[0011a] In one aspect, there is provided a multi-layered biodegradable sheet wherein at least one layer comprises a first hydrophobic polymer selected from the group consisting of poly(epsilon-caprolactone) (PCL), a polyhydroxyalkanoate (PHA) and a mixture thereof, and a second hydrophobic polymer selected from the group consisting of polybutylene succinate (PBS), polybutylene succinate adipate (PBSA), poly lactic acid (PLA), polybutylene adipate terephthalate (PBAT), polydioxanone (PDO), polyglycolic acid (PGA) and any mixture thereof, the biodegradable sheet further comprising at least one additional layer comprising a polymer selected from the group consisting of PBS, PBSA and a mixture thereof.

What is claimed is:

1. A multi-layered biodegradable sheet wherein at least one layer comprises a first hydrophobic polymer selected from the group consisting of poly(epsilon-caprolactone) (PCL), a polyhydroxyalkanoate (PHA) and a mixture thereof, and a second hydrophobic polymer selected from the group consisting of polybutylene succinate (PBS), polybutylene succinate adipate (PBSA), poly lactic acid (PLA), polybutylene adipate terephthalate (PBAT), polydioxanone (PDO), polyglycolic acid (PGA) and any mixture thereof, the biodegradable sheet further comprising at least one additional layer comprising a polymer selected from the group consisting of PBS, PBSA and a mixture thereof.

2. The multi-layered biodegradable sheet of claim 1, wherein the PHA is selected from the group consisting of polyhydroxybutyrate (PHB), polyhydroxyvalerate (PHV), polyhydroxybutyrate-hydroxyvalerate copolymers (PHBV); and any derivative or mixture thereof.

3. The multi-layered biodegradable sheet of any one of claims 1 or 2, wherein the first hydrophobic polymer is present in an amount of 5% w/w to 45%w/w, 20% w/w to 45% w/w or 25% to 40% w/w of the layer.

4. The multi-layered biodegradable sheet of any one of claims 1 - 3, wherein the second hydrophobic polymer is present in at least one layer and is selected from the group consisting of PLA, PBS, PBSA and PBAT or a mixture thereof, wherein the mixture is optionally a mixture of PBS and PBSA, a mixture of PBS and PLA, a mixture of PBSA and PLA or a mixture of PBAT and PLA.

5. The multi-layered biodegradable sheet of claim 4, wherein the second hydrophobic polymer is present in the layer in an amount of 55% w/w to 95% w/w of the weight of the layer.

6. The multi-layered biodegradable sheet of any one of claims 1-5, consisting of 2, 3, 4, 5, 6 or 7 layers.

7. The multi-layered biodegradable sheet of any one of claims 1 to 6, wherein at least one layer consists of 60% PLA and 40% PCL w/w of the layer.

8. The multi-layered biodegradable sheet of claim 6, wherein the sheet is a two-layered sheet, optionally comprising a first layer comprising 70%-80% w/w PBS or PBSA and 20%-30% PLA and a second layer comprising 15%-25% w/w PLA, 50%-60% w/w PBS or PBSA and 5% -30% w/w PCL.

9. The multi-layered biodegradable sheet of claim 6, wherein the sheet is a three layered sheet, optionally comprising a first layer comprising 70%-80% w/w PBS or PBSA and 20%-30% PLA; a second layer comprising 70%-80% w/w PBS or PBSA and 20%-30% PLA; and a third layer comprising 5% -45% w/w PCL or PHA and 55% to 80% w/w PLA, PBS, PBSA, PBAT or a mixture thereof, wherein the second layer is an internal layer and the third layer is the contact layer.

10. The multi-layered biodegradable sheet of claim 6, wherein said at least one additional layer comprises 100% w/w PBS or PBSA.

11. The multi-layered biodegradable sheet of claim 6, wherein said at least one additional layer consists of 75% PBSA w/w and 25% PLA w/w of the layer.

12. The multi-layered biodegradable sheet of claim 6, wherein the sheet is a three layered sheet comprising a third layer comprising 15%-25% w/w PBSA or PLA, 50% -60% w/w PBAT or PBS and 5%-30% PCL.

13. The multi-layered biodegradable sheet of claim 6, comprising a three layered sheet comprising a first layer comprising 15%-25% w/w PBSA, 50% -60% w/w PBS and 20%-30% PCL.

14. The multi-layered biodegradable sheet of claim 1, comprising a contact layer comprising between 5% w/w to 45%w/w PCL or PHA or a mixture thereof; and a mixture of PBS and PBSA, a mixture of PBS and PLA, a mixture of PBSA and PLA, or a mixture of PBAT and PLA, in an amount of 95% w/w to 55%w/w.