- a special co-extrusion film die with a width of 1500 mm;
- a three-roll calender with horizontal roller arrangement, the third roller being capable of swivelling about +/- 45° in relation to the horizontal;
- a roller conveyor;
- a device for application of protective film on both surfaces;
- a take-off device;
- winding machine .

The granular material of the base material was supplied to the feed hopper of the main extruder. In the respective plasticising system constituted by cylinder/screw the melting and conveying of the respective material took place. Both material melts were brought together in the co-extrusion nozzle. From the nozzle the melt arrived at the calender. On the roll calender the definitive shaping and cooling of the material take place. For the purpose of structuring the surfaces of the film, in this connection two polished chromium rollers (for gloss/gloss surfaces) were employed. Subsequently the film was transported through a take-off, the protective film is applied on both sides, then the winding-up of the film took place.

With this film extrusion line , with a temperature of the main extruder from 220 °C to 240 °C and with a temperature of the co-extruder from 228 °C to 260 °C three-layer films according to the invention with two smooth, glossy sides with a layer thickness of 800 µm were extruded, the copolyester core layer of Copolyester I being 650 µm thick and the thermoplastic polyurethane layer on each side being in each instance 75 µm thick.

WHAT IS CLAIMED IS:

1. Multi-layer plastic film, characterised in that

   - it has a core layer A containing at least one polycarbonate or copolycarbonate and/or a polyester or copolyester having a glass transition temperature T_g from 80 °C to 200°C,

   - and this core layer A is located between two outer layers B containing at least one thermoplastic polyurethane and/or polyester or copolyester exhibiting a hardness from 45 Shore D to 85 Shore D.

2. Multi-layer plastic film according to claim 1, characterised in that it has a core layer A containing at least one polyester or copolyester having an inherent viscosity from 0.50 dL/g to 1.20 dL/g and a glass transition temperature T_g from 80 °C to 200°C.

3. Multi-layer plastic film according to claim 1 or 2, characterised in that the two outer layers B containing at least one thermoplastic polyurethane exhibiting a hardness from 45 Shore D to 85 Shore D.

4. Multi-layer plastic film according to at least one of Claims 1 to 3, characterised in that

   - it has a core layer A containing at least one copolyester that exhibits residues from

     (a) a dicarboxylic acid component comprising

        i) 70 mole % to 100 mole % terephthalic acid residues,

        ii) 0 mole % to 30 mole % aromatic dicarboxylic acid residues with up to 20 carbon atoms, and

        iii) 0 mole % to 10 mole % aliphatic dicarboxylic acid residues with up to 16 carbon atoms, and

(b) a diol component comprising

i) 5 mole % to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, and

ii) 50 mole % to 95 mole % 1,4-cyclohexanedimethanol residues,

wherein the sum of the mole % of residues i) – iii) of the dicarboxylic acid component amounts to 100 mole % and the sum of the mole % of residues i) and ii) of the diol component amounts to 100 mole %

and wherein the inherent viscosity of the copolyester amounts to 0.50 dL/g to 1.20 dL/g and the copolyester exhibits a glass transition temperature T_g from 80 °C to 150 °C,

- and this core layer is located between two outer layers B containing at least one thermoplastic polyurethane, the thermoplastic polyurethane exhibiting a hardness from 45 Shore D to 85 Shore D and being obtainable from

a) one or more linear polyether diols with mean molecular weights from 500 g/mol to 10,000 g/mol, preferably 500 g/mol to 6000 g/mol, and, on average, in each instance at least 1.8 and at most 3.0, preferably 1.8 to 2.2, Tserevitinov-active hydrogen atoms

b) one or more organic diisocyanates

c) one or more diol chain-extenders with molecular weights from 60 g/mol to 500 g/mol and with, on average, 1.8 to 3.0 Tserevitinov-active hydrogen atoms

in the presence of

d) optionally, one or more catalysts

with addition of

e) optionally, auxiliary substances and additives,

wherein the molar ratio of the NCO groups in b) to the groups in a) and c) that are reactive towards isocyanate amounts to 0.85:1 to 1.2:1, preferably 0.9:1 to 1.1:1.

5. Multi-layer plastic film according to at least one of Claims 1 to 4, characterised in that the thermoplastic polyurethane exhibits a hardness from 50 Shore D to 80 Shore D.

6. Multi-layer plastic film according to Claim 4 or 5, characterised in that the polyether diols a) used for producing the thermoplastic polyurethane are selected from one or more polyether diols of the group based on 1,4-butanediol units and/or 1,3-propylene glycol units.

7. Multi-layer plastic film according to at least one of Claims 4 to 6, characterised in that the organic diisocyanate b) used for producing the thermoplastic polyurethane is selected from one or more isocyanates of the group containing 4,4'-diphenylmethane diisocyanate, isophorone diisocyanate, dicyclohexylmethane-4,4'-diisocyanate or 1,6-hexamethylene diisocyanate.

8. Multi-layer plastic film according to at least one of Claims 4 to 7, characterised in that the diol chain-extender c) used for producing of the thermoplastic polyurethane is selected from one or more chain-extenders of the group containing 1,4-butanediol, 1,3-propanediol, 1,2-propanediol, 1,2-ethylene glycol, 1,6-hexanediol, 1,4-di(β-hydroxyethyl)hydroquinone or 1,4-di(β-hydroxyethyl)bisphenol A.

9. Multi-layer plastic film according to at least one of Claims 4 to 8, characterised in that the thermoplastic polyurethane was produced in the prepolymer process.

10. Multi-layer plastic film according to at least one of Claims 4 to 9, characterised in that the diol component of the copolyester comprises 10 mole % to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 65 mole % to 90 mole % 1,4-cyclohexanedimethanol residues, preferably 15 mole % to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 65 mole % to 85 mole % 1,4-cyclohexanedimethanol residues, particularly preferably 15 mole % to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 70 mole % to 85 mole % 1,4-cyclohexanedimethanol residues, the sum of the mole % of these two components of the diol component amounting to 100 mole %.

11. Multi-layer plastic film according to at least one of Claims 4 to 10, characterised in that the residues from the dicarboxylic acid component of the polyester include 95 mole % to 100 mole % terephthalic acid residues.

12. Multi-layer plastic film according to at least one of Claims 1 to 11, characterised in that the film has been co-extruded.

13. Multi-layer plastic film according to at least one of Claims 1 to 12, characterised in that it has a total thickness from 300 µm to 2000 µm, preferably from 400 µm to 1500 µm, particularly preferably from 500 µm to 1200 µm.

14. Multi-layer plastic film according to at least one of Claims 1 to 13, characterised in that the core layer A has a layer thickness from 250 µm to 1600 µm, preferably from 350 µm to 1400 µm, particularly preferably from 400 µm to 1000 µm.

15. Multi-layer plastic film according to at least one of Claims 1 to 14, characterised in that the outer layers B each have a layer thickness from 25 µm to 500 µm, preferably from 30 µm to 300 µm, particularly preferably from 50 µm to 200 µm.

16. Multi-layer plastic film according to at least one of Claims 2 to 15, characterised in that the poly- or copolyester exhibits an inherent viscosity from 0.50 dL/g to 0.80 dL/g.

17. Multi-layer plastic film according to at least one of Claims 1 to 16, characterised in that the poly- or copolyester exhibits a glass transition temperature T_g from 85 °C to 130 °C, preferably from 90 °C to 120 °C.

18. Three-dimensionally shaped article obtained by three-dimensionally forming the multi-layer plastic film according to at least one of Claims 1 to 17.

CLAIMS

1. Multi-layer plastic film, characterised in that

   - it has a core layer A containing at least one polycarbonate or copolycarbonate and/or a copolyester having a glass transition temperature T_g from 80 °C to 200°C,

   - and this core layer A is located between two outer layers B containing at least one thermoplastic polyurethane and/or polyester or copolyester exhibiting a hardness from 45 Shore D to 85 Shore D.

2. Multi-layer plastic film according to claim 1, characterised in that it has a core layer A containing at least one copolyester having an inherent viscosity from 0.50 dL/g to 1.20 dL/g and a glass transition temperature T_g from 80 °C to 200°C.

3. Multi-layer plastic film according to claim 1 or 2, characterised in that the two outer layers B containing at least one thermoplastic polyurethane exhibiting a hardness from 45 Shore D to 85 Shore D.

4. Multi-layer plastic film according to at least one of Claims 1 to 3, characterised in that

   - it has a core layer A containing at least one copolyester that exhibits residues from

     (a) a dicarboxylic acid component comprising

        i) 70 mole % to 100 mole % terephthalic acid residues,

        ii) 0 mole % to 30 mole % aromatic dicarboxylic acid residues with up to 20 carbon atoms, and

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     (b) a diol component comprising

        i) 5 mole % to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, and

        ii) 50 mole % to 95 mole % 1,4-cyclohexanedimethanol residues,

wherein the sum of the mole % of residues i) – iii) of the dicarboxylic acid component amounts to 100 mole % and the sum of the mole % of residues i) and ii) of the diol component amounts to 100 mole %

and wherein the inherent viscosity of the copolyester amounts to 0.50 dL/g to 1.20 dL/g and the copolyester exhibits a glass transition temperature T_g from 80 °C to 150 °C,

- and this core layer is located between two outer layers B containing at least one thermoplastic polyurethane, the thermoplastic polyurethane exhibiting a hardness from 45 Shore D to 85 Shore D and being obtainable from

a) one or more linear polyether diols with mean molecular weights from 500 g/mol to 10,000 g/mol, preferably 500 g/mol to 6000 g/mol, and, on average, in each instance at least 1.8 and at most 3.0, preferably 1.8 to 2.2, Tserevitinov-active hydrogen atoms

b) one or more organic diisocyanates,

c) one or more diol chain-extenders with molecular weights from 60 g/mol to 500 g/mol and with, on average, 1.8 to 3.0 Tserevitinov-active hydrogen atoms

in the presence of

d) optionally, one or more catalysts

with addition of

e) optionally, auxiliary substances and additives,

wherein the molar ratio of the NCO groups in b) to the groups in a) and c) that are reactive towards isocyanate amounts to 0.85:1 to 1.2:1, preferably 0.9:1 to 1.1:1.

5. Multi-layer plastic film according to at least one of Claims 1 to 4, characterised in that the thermoplastic polyurethane exhibits a hardness from 50 Shore D to 80 Shore D.

6. Multi-layer plastic film according to Claim 4 or 5, characterised in that the polyether diols a) used for producing the thermoplastic polyurethane are selected from one or more

polyether diols of the group based on 1,4-butanediol units and/or 1,3-propylene glycol units.

7. Multi-layer plastic film according to at least one of Claims 4 to 6, characterised in that the organic diisocyanate b) used for producing the thermoplastic polyurethane is selected from one or more isocyanates of the group containing 4,4'-diphenylmethane diisocyanate, isophorone diisocyanate, dicyclohexylmethane-4,4'-diisocyanate or 1,6-hexamethylene diisocyanate.

8. Multi-layer plastic film according to at least one of Claims 4 to 7, characterised in that the diol chain-extender c) used for producing of the thermoplastic polyurethane is selected from one or more chain-extenders of the group containing 1,4-butanediol, 1,3-propanediol, 1,2-propanediol, 1,2-ethylene glycol, 1,6-hexanediol, 1,4-di(β-hydroxyethyl)hydroquinone or 1,4-di(β-hydroxyethyl)bisphenol A.

9. Multi-layer plastic film according to at least one of Claims 4 to 8, characterised in that the thermoplastic polyurethane was produced in the prepolymer process.

10. Multi-layer plastic film according to at least one of Claims 4 to 9, characterised in that the diol component of the copolyester comprises 10 mole % to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 65 mole % to 90 mole % 1,4-cyclohexanedimethanol residues, preferably 15 mole % to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 65 mole % to 85 mole % 1,4-cyclohexanedimethanol residues, particularly preferably 15 mole % to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 70 mole % to 85 mole % 1,4-cyclohexanedimethanol residues, the sum of the mole % of these two components of the diol component amounting to 100 mole %.

11. Multi-layer plastic film according to at least one of Claims 4 to 10, characterised in that the residues from the dicarboxylic acid component of the polyester include 95 mole % to 100 mole % terephthalic acid residues.

12. Multi-layer plastic film according to at least one of Claims 1 to 11, characterised in that the film has been co-extruded.

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14. Multi-layer plastic film according to at least one of Claims 1 to 13, characterised in that the core layer A has a layer thickness from 250 µm to 1600 µm, preferably from 350 µm to 1400 µm, particularly preferably from 400 µm to 1000 µm.

15. Multi-layer plastic film according to at least one of Claims 1 to 14, characterised in that the outer layers B each have a layer thickness from 25 µm to 500 µm, preferably from 30 µm to 300 µm, particularly preferably from 50 µm to 200 µm.

16. Multi-layer plastic film according to at least one of Claims 2 to 15, characterised in that the copolyester exhibits an inherent viscosity from 0.50 dL/g to 0.80 dL/g.

17. Multi-layer plastic film according to at least one of Claims 1 to 16, characterised in that the copolyester exhibits a glass transition temperature T_g from 85 °C to 130 °C, preferably from 90 °C to 120 °C.

18. Three-dimensionally shaped article obtained by three-dimensionally forming the multi-layer plastic film according to at least one of Claims 1 to 17.