Supporting Information:

High triplet energy electron transport side-chain polystyrenes containing dimesitylboron and tetraphenylsilane for solution processed OLEDs

Alejandro Lorente, Patrick Pingel, Hartmut Krüger,* Silvia Janietz

Fraunhofer Institute for Applied Polymer Research, Wissenschaftspark Golm, Geiselbergstr. 69, D-14476 Potsdam, Germany

*Corresponding Author. Email: hartmut.krueger@iap.fraunhofer.de

Table of Contents

Monomer synthesis	2
Polymer synthesis	8
Cyclovoltammetry	10
References	10

Monomer synthesis

General: (4-Bromophenyl)triphenylsilane **1a**, bis(4-bromophenyl)diphenylsilane **1b** and tris(4-bromophenyl)-(phenyl)silane **1c** were synthesized according to previously described procedures.¹

General technique I: 4-(Triphenylsilyl)benzaldehyde (2)

To a solution of (4-bromophenyl)triphenylsilane **1a** (8.00 g, 19.3 mmol) in *anhydrous* tetrahydrofuran (50 mL) cooled to -78 °C, *n*-butyllithium 1.6 M in hexane was added dropwise (9.24 mL, 23.1 mmol). The mixture was stirred at this temperature for 1.5 hours and then *N*,*N*-dimethylformamide (2.82 g, 38.5 mmol) was added. The reaction was let to warm up to room temperature and stirred for 3 hours until the full consumption of the starting material was observed by TLC analysis. Subsequently, aqueous HCl 1 N (30 mL) was added to the mixture and stirred at room temperature for 0.5 hours. Evaporation of tetrahydrofuran under reduced pressure was followed by extraction of the aqueous phase with dichloromethane. The combined organic phases where dried over MgSO₄, filtered and concentrated. The reaction crude was purified by silica gel column chromatography using heptane/ethyl acetate (9:1) as eluent. Recrystallization with ethanol/dichloromethane mixtures gave **2** as a white solid. Yield: 5.69 g (81%).²

¹H NMR (500 MHz, CDCl₃, δ): 10.07 (s, 1H), 7.88 (d, J = 7.7 Hz, 2H), 7.78 (d, J = 7.9 Hz, 2H), 7.64 – 7.53 (m, 10H), 7.52 – 7.32 (m, 15H).

¹³C NMR (126 MHz, CDCl₃, δ): 192.72, 143.24, 137.06, 137.02, 136.52, 136.47, 134.32, 133.27, 130.10, 129.72, 128.77, 128.22, 128.00.

General technique II: triphenyl(4-vinylphenyl)silane (3)

A mixture of potassium *tert*-butoxide (2.31 g, 20.6 mmol) and methyltriphenylphosphonium bromide (6.81 g, 19.1 mmol) was suspended in *anhydrous* tetrahydrofuran (15 mL). The reaction mixture was cooled to 0 °C and stirred for 0.5 hours under argon atmosphere. 4-(Triphenylsilyl)benzaldehyde **2** (4.60 g, 12.6 mmol) was dissolved in tetrahydrofuran (15 mL), added dropwise to the mixture and stirred for 1.5 hours at 0 °C. After completion of the reaction, the solvent was evaporated; water was added to the crude and then extracted with dichloromethane. The combined organic phase was dried over MgSO₄. The crude was purified

by silica gel chromatography using heptane/toluene (9:1) as eluent gave **3** as a white solid. Yield: 0.45 g (37%).³

¹H NMR (500 MHz, CDCl₃, δ): 7.58 (dd, *J* = 17.8, 7.8 Hz, 8H), 7.49 – 7.32 (m, 11H), 6.76 (dd, *J* = 18.1, 10.4 Hz, 1H), 5.83 (d, *J* = 17.6 Hz, 1H), 5.31 (d, *J* = 10.9 Hz, 1H).

¹³C NMR (126 MHz, CDCl₃, δ): 138.79, 136.91, 136.79, 136.51, 134.31, 133.96, 129.75, 128.02, 125.79, 114.83.

General Technique III: dimesityl(4-vinyl-phenyl)borane (5)

A solution of 4-bromovinylbenzene **4** (3.79 g, 20.7 mmol) in *anhydrous* tetrahydrofuran (150 mL) was cooled to -78 °C before *n*-butyllithium 1.6 M in hexane (12.9 mL, 18.6 mmol) was added dropwise. The reaction mixture was stirred at this temperature for 1.5 hours. In a separated flask, dimesitylboron fluoride (5.00 g, 18.6 mmol) was dissolved in tetrahydrofuran and added dropwise to the previous solution and stirred at -78 °C for 30 minutes. The reaction mixture was let to warm to room temperature before it was heated at 50 °C for 2 hours. Subsequently, the reaction was cooled to room temperature and quenched with methanol (5 mL). After removal of the solvent under reduced pressure, water was added and the aqueous phase was extracted with dichloromethane. The combined organic fractions where dried over MgSO₄, filtered and the solvent was removed under reduced pressure. The crude product was purified by silica gel chromatography using toluene/heptane (1:9) as eluent. Product **5** was recrystallized using ethanol/dichloromethane mixtures. Yield: 3.80 g (57%).

¹H NMR (500 MHz, $CDCl_3$, δ): 7.49 (d, J = 8.0 Hz, 2H), 7.39 (d, J = 8.0 Hz, 2H), 6.83 (s, 4H), 6.75 (dd, J = 17.6, 10.9 Hz, 1H), 5.86 (d, J = 17.6 Hz, 1H), 5.33 (d, J = 11.0 Hz, 1H), 2.32 (s, 6H), 2.02 (s, 12H).

¹³C NMR (126 MHz, CDCl₃, δ): 145.54, 141.86, 140.94, 138.72, 136.99, 136.97, 128.29, 125.93, 115.63, 23.59, 21.37.

(4-Bromophenyl)(4-(dimesitylboranyl)phenyl)diphenylsilane (6)

According to general technique III, bis(4-bromophenyl)diphenylsilane **1b** (5.98 g, 12.09 mmol), *n*-butyllithium 1.6 M in hexane (8.3 mL, 13.3 mmol), and dimesitylboron fluoride (3.57 g, 13.3 mmol) were used. Yield: 5.76 g (76%).

¹H NMR (500 MHz, CDCl₃, δ): 7.59 – 7.47 (m, 10H), 7.45 – 7.36 (m, 8H), 6.81 (s, 4H), 2.30 (s, 6H), 2.01 (s, 12H).

¹³C NMR (126 MHz, CDCl₃, δ): 140.90, 138.90, 138.04, 137.94, 136.54, 136.43, 135.88, 135.20, 133.55, 133.24, 131.24, 129.98, 128.31, 128.13, 128.01, 124.92, 23.58, 21.37.

(4-(Dimesitylboranyl)phenyl)diphenyl(4'-vinyl-[1,1'-biphenyl]-4-yl)silane (7)

A mixture of (4-Bromophenyl)(4-(dimesitylboranyl)phenyl)diphenylsilane **6** (2.50 g, 3.91 mmol), 4-vinylphenylboronic acid (0.96 g, 6.49 mmol), sodium carbonate (5.30 g, 50 mmol) and tetrakis(triphenylphosphine)palladium(0) (0.23 g, 0.20 mmol) was dissolved in tetrahydrofuran (50 mL) and water (30 mL). The solution was purged from oxygen applying three vacuum-argon cycles before heat to 100 °C for 4 hours. After completion of the reaction, water was added to the mixture. Phase separation was followed by extraction with ethyl acetate. The combined organic fractions were dried over MgSO₄. The crude product was purified by neutral aluminum oxide column chromatography using chloroform/ hexane (1:9) as eluent. Yield: 0.61 g, (22%).⁴

¹H NMR (500 MHz, CDCl₃, δ): 7.65 – 7.58 (m, 12H), 7.50 (dd, *J* = 8.2, 2.1 Hz, 4H), 7.47 – 7.42 (m, 2H), 7.39 (dd, *J* = 7.8, 6.5 Hz, 4H), 6.81 (s, 4H), 6.76 (dd, *J* = 17.6, 10.9 Hz, 1H), 5.80 (d, *J* = 18.3 Hz, 1H), 5.28 (d, *J* = 11.6 Hz, 1H), 2.30 (s, 6H), 2.02 (s, 12H).

¹³C NMR (126 MHz, CDCl₃, δ): 147.24, 141.90, 140.91, 140.36, 138.84, 138.59, 137.02, 136.97, 136.53, 135.98, 135.18, 134.12, 133.03, 129.83, 128.29, 128.06, 127.38, 126.82, 126.50, 114.17, 23.59, 21.37., 21.23.

4-((4-Bromophenyl)diphenylsilyl)benzaldehyde (8a)

According to general technique I, bis(4-bromophenyl)diphenylsilane **1b** (1.47 g, 2.97 mmol), *n*-butyllithium 1.6 M in hexane (2.04 mL, 3.27 mmol) and *N*,*N*-dimethylformamide (0.44 g, 6.00 mmol) were used. Yield: 1.17 g (88%).

¹H NMR (500 MHz, CDCl₃, δ): 10.05 (s, 1H), 7.87 (d, *J* = 7.6 Hz, 2H), 7.73 (d, *J* = 7.6 Hz, 2H), 7.61 – 7.48 (m, 10H), 7.47 – 7.33 (m, 12H).

¹³C NMR (126 MHz, CDCl₃, δ): 192.63, 142.53, 137.97, 137.19, 136.94, 136.38, 132.68, 132.32, 131.46, 130.31, 128.86, 128.34, 125.28.

4-(Bis(4-bromophenyl)(phenyl)silyl)benzaldehyde (8b)

According to general technique I, tris(4-bromophenyl)(phenyl)silane **1c** (7.22 g, 12.6 mmol), *n*-butyllithium 1.6 M in hexane (8.66 mL, 13.9 mmol), *N*,*N*-dimethylformamide (1.84 g, 25.2 mmol) were used. Yield: 4.25 g (65%).

¹H NMR (500 MHz, CDCl₃, δ): 10.06 (s, 1H), 7.88 (d, *J* = 8.1 Hz, 2H), 7.71 (d, *J* = 8.0 Hz, 2H), 7.58 – 7.48 (m, 7H), 7.47 – 7.35 (m, 7H).

¹³C NMR (126 MHz, CDCl₃, δ): 192.54, 141.82, 137.87, 137.33, 136.87, 136.30, 132.09, 131.72, 131.59, 130.52, 128.94, 128.46, 125.52.

General technique IV: (4-(1,3-dioxan-2-yl)phenyl)(4-bromophenyl)diphenylsilane (9a)

A mixture of 4-((4-bromophenyl)diphenylsilyl)benzaldehyde **8a** (4.00 g, 9.02 mmol), 1,3propanediol (2.75 g, 36.1 mmol), and *p*-toluenesulfonic acid (0.09 mg, 0.54 mmol) dissolved in *anhydrous* toluene (60 mL) was heated to 150 °C using a *Dean-Stark* apparatus for the removal of water formed during the condensation reaction. The mixture was heated at this temperature for 3 hours. Afterwards, the reaction was cooled to room temperature and the solvent was evaporated. The reaction crude was absorbed on silica gel, and purified by silica gel column chromatography using heptane/ethyl acetate (4:1) as eluent. Recrystallization in methanol/dichloromethane mixture gave **9a** as a white solid. Yield: 2.58 g (57%).

¹H NMR (500 MHz, CDCl₃, δ): 7.58 – 7.49 (m, 10H), 7.46 – 7.35 (m, 8H), 5.54 (s, 1H), 4.35 – 4.20 (m, 2H), 4.01 (td, *J* = 12.3, 2.1 Hz, 2H), 2.25 (qt, *J* = 12.5, 4.9 Hz, 1H), 1.46 (d, *J* = 13.5 Hz, 1H).

¹³C NMR (126 MHz, CDCl₃, δ): 140.26, 138.05, 136.53, 136.43, 134.50, 133.62, 133.29, 131.20, 129.93, 128.09, 125.70, 124.87, 101.61, 67.57, 25.90.

(4-(1,3-Dioxan-2-yl)phenyl)bis(4-bromophenyl)(phenyl)silane (9b)

According to general technique IV, **8b** (4.25 g, 8.13 mmol), 1,3-propanediol (2.48 g, 32.5 mmol) and *p*-toluenesulfonic acid (0.08 g, 0.49 mmol) were used. Yield: 3.22 g (70%).

¹H NMR (500 MHz, $CDCl_3$, δ): 7.58 – 7.42 (m, 12H), 7.38 (d, J = 7.4 Hz, 5H), 5.54 (s, 1H), 4.29 (dd, J = 11.5, 4.8 Hz, 2H), 4.01 (t, J = 11.6 Hz, 2H), 2.24 (dtd, J = 17.7, 12.7, 6.3 Hz, 1H), 1.47 (d, J = 13.5 Hz, 1H).

¹³C NMR (126 MHz, CDCl₃, δ): 140.49, 137.94, 136.44, 136.34, 133.87, 133.02, 132.67, 131.32, 130.14, 128.21, 125.83, 125.11, 101.51, 67.58, 25.89.

(4-(1,3-Dioxan-2-yl)phenyl)(4-(dimesityl-boranyl)phenyl)diphenylsilane (10a)

According to general technique III, (4-(1,3-dioxan-2-yl)phenyl)(4-bromophenyl)diphenylsilane **10a** (2.58 g, 5.14 mmol), *n*-butyllithium 1.6 M in hexane (4.81 mL, 7.71 mmol), and dimesitylboron fluoride (2.07 g, 7.71 mmol) were used. Yield: 2.34 g (67%).

¹H NMR (500 MHz, CDCl₃, δ): 7.63 – 7.30 (18H, m), 6.81 (4H, s), 5.53 (1H, d, *J*=3.8 Hz), 4.28 (2H, d, *J*=10.7 Hz), 4.00 (2H, t, *J*=12.2, 12.2 Hz), 2.30 (6H, s), 2.28 – 2.15 (1H, m), 2.01 (12H, s), 1.46 (1H, d, *J*=13.4 Hz).

¹³C NMR (126 MHz, CDCl₃, δ): 141.87, 140.91, 140.12, 138.81, 138.33, 136.54, 136.51, 135.97, 135.10, 134.82, 133.82, 129.81, 128.29, 127.99, 127.03, 125.57, 101.59, 67.52, 25.91, 23.57, 21.36.

(4-(1,3-Dioxan-2-yl)phenyl)bis(4-(dimesityl-boranyl)phenyl)(phenyl)silane (10b)

According to general technique III, (4-(1,3-Dioxan-2-yl)phenyl)bis(4-bromophenyl)(phenyl)silane **9b** (3.32 g, 5.72 mmol), *n*-butyllithium 1.6 M in hexane (8.94 mL, 14.3 mmol) and dimesitylboron fluoride (3.84 g, 14.30 mmol) were used. Yield: 4.06 g (77%).

The formation of product **10b** was confirmed by using dinitrophenylhydrazine (DNP) stain solution, which reacts selectively with aldehydes and ketones. In this case aldehyde-protected product showed a higher R_f (0.5) than **9b** (0.3) and the characteristic orange spot was not observed.

General Technique V: 4-((4-(Dimesityl-boranyl)phenyl)diphenylsilyl)-benzaldehyde (11a)

To a solution of (4-(1,3-dioxan-2-yl)phenyl)(4-(dimesityl-boranyl)phenyl)diphenylsilane 25a (2.00 g, 2.98 mmol) in tetrahydrofuran (30 mL) and water (10 mL),*p*-toluenesulfonic acid (30 mg, 0.18 mmol) was added. The reaction was then heated to 100 °C for 20 hours until the full consumption of the starting material was observed by TLC analysis. Afterwards, the reaction was cooled to room temperature and tetrahydrofuran was removed under reduced pressure. Addition of water was followed by extraction with dichloromethane. The combined organic fractions were dried over MgSO₄, filtered and concentrated. The reaction crude was purified by silica gel column chromatography using toluene/heptane (5:95) as eluent. Yield: 1.07 g (60%).

The formation of product **11a** was confirmed by using dinitrophenylhydrazine (DNP) stain solution, which reacts selectively with aldehydes and ketones. In this case, aldehyde **11a** showed a lower R_f (0.4) than **10a** (0.6) and the characteristic orange spot was observed after revealing the TLC plate.

4-(Bis(4-(dimesitylboranyl)phenyl)(phenyl)-silyl)benzaldehyde (11b)

According to general technique IV, (4-(1,3-dioxan-2-yl)phenyl)bis(4-(dimesitylboranyl)phenyl)(phenyl)silane **10b** (3.70 g, 4.03 mmol) and *p*-toluenesulfonic acid (0.04 g, 0.24 mmol) were used. Yield: 1.95 g (56%).

¹H NMR (500 MHz, CDCl₃, δ): 10.04 (s, 1H), 7.85 (d, *J* = 7.7 Hz, 2H), 7.72 (d, *J* = 7.7 Hz, 2H), 7.56 – 7.35 (m, 13H), 6.81 (s, 8H), 2.30 (s, 12H), 2.01 (s, 24H).

¹³C NMR (126 MHz, CDCl₃, δ): 192.70, 147.67, 142.93, 141.79, 140.91, 138.95, 137.22, 137.09, 136.99, 136.43, 135.92, 135.24, 132.92, 130.19, 128.78, 128.33, 128.24, 23.58, 21.37.

(4-(Dimesitylboranyl)phenyl)diphenyl(4-vinylphenyl)silane (12a)

According to general technique II, 4-((4-(dimesityl-boranyl)phenyl)diphenylsilyl)-benzaldehyde **11a** (1.00 g, 1.63 mmol), potassium *tert*-butoxide (0.30 g, 2.66 mmol) and methyltriphenylphosphonium bromide (0.87 g, 2.45 mmol) were used. Purification by silica gel column chromatography using heptane/ethyl acetate (9:1), followed by recrystallization using ethanol/dichloromethane mixtures gave **12a** as a white solid. Yield: 0.43 g, 0.71 mmol (71%). ¹H NMR (500 MHz, CDCl₃, δ): 7.58 – 7.35 (m, 18H), 6.81 (s, 4H), 6.74 (dd, *J* = 17.6, 10.9 Hz, 1H), 5.81 (d, *J* = 17.6, 0.7 Hz, 1H), 5.29 (d, *J* = 10.5, 1H), 2.30 (s, 6H), 2.02 (s, 12H).

¹³C NMR (126 MHz, CDCl₃, δ): 147.20, 141.88, 140.91, 138.83, 138.59, 136.88, 136.77, 136.50, 135.95, 135.15, 134.11, 133.76, 129.80, 128.29, 128.03, 125.80, 114.87, 23.58, 21.37.

Bis(4-(dimesitylboranyl)phenyl)(phenyl)(4-vinylphenyl)silane (12b)

According to general technique II, 4-(bis(4-(dimesitylboranyl)phenyl)(phenyl)silyl)benzaldehyde **11b** (1.93 g. 2.24 mmol), potassium *tert*-butoxide (0.40 g, 3.58 mmol) and methyltriphenylphosphonium bromide (1.20 g, 3.36 mmol) were used. Purification by silica gel column chromatography using heptane/ethyl acetate (9:1), followed by recrystallization using methanol/dichloromethane mixtures gave **12b** as a white solid. Yield: 1.47g, 1.71 mmol (88%).

¹H NMR (500 MHz, CDCl₃, δ): 7.49 – 7.38 (m, 12H), 7.37 – 7.27 (m, 5H), 6.74 (s, 8H), 6.66 (dd, J = 17.6, 10.9 Hz, 1H), 5.73 (d, J = 17.6 Hz, 1H), 5.22 (d, J = 10.9 Hz, 1H), 2.23 (s, 12H), 1.94 (s, 24H).

¹³C NMR (126 MHz, CDCl₃, δ): 147.26, 141.87, 140.92, 138.84, 138.39, 136.86, 136.74, 136.47, 135.96, 135.14, 133.94, 133.59, 129.84, 128.29, 128.04, 125.81, 114.89, 23.59, 21.37.

Polymer synthesis

General technique VI: Poly(triphenyl(4-vinylphenyl)silane) (P1)

Polymer **P1**, from **3**: The monomer concentration was set to be 100 g/L in freshly distilled tetrahydrofuran. *N*,*N*-Azobisisobutyronitrile (2 mol%) was used as initiator. The reaction was carried out in a glove box system under nitrogen atmosphere at 50 °C for 72 hours. After cooling to room temperature the reaction was quenched with methanol. Demonomerization was achieved by repeated precipitation into methanol/ethyl acetate mixtures. The residue was dissolved again in tetrahydrofuran and filtered through syringe PTFE filter 0.2 μ m. The solution was concentrated and precipitated again into methanol. The precipitate was filtered by the use of PTFE filters pore size 0.45 μ m. The polymer was dried overnight at 50 °C in vacuum. Yield: 0.54 g (63%).

¹H NMR (500 MHz, CDCl₃, δ): 7.7-6.7 (aromatics), 6.7-6.0 (aromatics), 2.4-1.6 (backbone). Elemental analysis, calculated: C, 86.14; H, 6.12; Si, 7.75; found: C, 86.31; H, 6.26. T_g = 200 °C; $M_n = 16.3 \text{ kg mol}^{-1}$; $M_w = 40.2 \text{ kg mol}^{-1}$; PD = 2.47; DP = 44.

Poly(dimesityl(4-vinyl-phenyl)borane) (P2)

Polymer **P2**, from **5**: The same procedure as for **P1** was employed. After cooling to room temperature and quenching with methanol, the mixture was diluted with tetrahydrofuran. Precipitations were carried out in methanol. Yield: 0.38 g (79%).

¹H NMR (500 MHz, CDCl₃, δ): 7.2-7.0 (aromatics), 6.9-6.1 (aromatics), 2.4-2.0 (backbone), 2.0-1.6 (backbone). Elemental analysis, calculated: C, 88.64; H, 8.30; B, 3.07; found: C, 88.47; H, 8.76. T_g = 202 °C; M_n = 18.7 kg mol⁻¹; M_w = 77.2 kg mol⁻¹; PD = 4.13; DP = 53.

Poly[(4-(dimesitylboranyl)phenyl)diphenyl(4-vinylphenyl)silane] (P3)

Polymer **P3**, from **12a**: The same procedure as for **P1** was employed. After cooling to room temperature and quenching with methanol, the mixture was diluted with tetrahydrofuran. Precipitations were carried out in methanol/ethyl acetate (2:1) mixtures. Yield: 0.42 g (73%).

¹H NMR (500 MHz, $CDCl_3$, δ): 7.6-7.0 (aromatics), 7.0-6.1 (aromatics), 2.3-2.1 (backbone), 2.0-1.6 (backbone). Elemental analysis, calculated: C, 86.53; H, 7.10; B, 1.77; Si, 4.60; found: C, 86.46; H, 7.28. T_g = 187 °C; M_n = 15.6 kg mol⁻¹; M_w = 46.3 kg mol⁻¹; PD = 2.96; DP = 25.

Poly[(4-(dimesitylboranyl)phenyl)diphenyl(4'-vinyl-[1,1'-biphenyl]-4-yl)silane] (P4)

Polymer **P4**, from **7**: The same procedure as for **P1** was employed. After cooling to room temperature and quenching with methanol, the mixture was diluted with tetrahydrofuran. Precipitations were carried out in methanol/ethyl acetate (2:1) mixtures. Yield: 0.19 g (37%).

¹H NMR (500 MHz, THF-*d*, δ): 7.6-7.3 (aromatics), 7.3-7.2 (aromatics), 7.2-6.9 (aromatics), 2.2-2.0 (backbone). Elemental analysis, calculated: C, 87.44; H, 6.90; B, 1.57; Si, 4.09; found: C, 87.33; H, 7.00. T_g = 214 °C; M_n = 32.7 kg mol⁻¹; M_w = 60.0 kg mol⁻¹; PD = 1.84; DP = 47.

Poly[bis(4-(dimesitylboranyl)phenyl)(phenyl)(4-vinylphenyl)silane] (P5)

Polymer **P5**, from **12b**: The same procedure as for **P1** was employed. After cooling to room temperature and quenching with methanol, the mixture was diluted with tetrahydrofuran. Precipitations were carried out in methanol/ethyl acetate (2:1) mixtures. Yield: 0.35 g (51%).

¹H NMR (500 MHz, $CDCl_3$, δ): 7.7-7.1 (aromatics), 7.1-6.2 (aromatics), 2.4-2.1 (backbone), 2.0-1.4 (backbone). Elemental analysis, calculated: C, 86.70; H, 7.51; B, 2.52; Si, 3.27; found: C, 84.82; H, 7.70. T_g = n.d.; M_n = 13.3 kg mol⁻¹; M_w = 20.8 kg mol⁻¹; PD = 1.56; DP = 15.

Cyclovoltammetry



Figure S1. Exemplary cyclovoltammogram of polymer P3. The oxidation and reduction potential were taken from the onset of the corresponding peak marked with a star.

References

- 1 H. Liu, Q. Bai, L. Yao, D. Hu, X. Tang, F. Shen, H. Zhang, Y. Gao, P. Lu, B. Yang and Y. Ma, *Adv. Funct. Mater.*, 2014, **24**, 5881–5888.
- 2 M. Debeaux, M. W. Thesen, D. Schneidenbach, H. Hopf, S. Janietz, H. Krüger, A. Wedel, W. Kowalsky and H.-H. Johannes, *Adv. Funct. Mater.*, 2010, **20**, 399–408.
- 3 M. W. Thesen, B. Höfer, M. Debeaux, S. Janietz, A. Wedel, A. Köhler, H.-H. Johannes and H. Krueger, J. Polym. Sci. Part Polym. Chem., 2010, **48**, 3417–3430.
- 4 B. C. D. Salert, A. Wedel, L. Grubert, T. Eberle, R. Anémian and H. Krueger, *Adv. Mater. Sci. Eng.*, 2012, **2012**, 385178.