*Supplementary Materials*

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**Table S1.** Preparation of PPCDL-TPU with Different R Values

| Samples | Diol | Isocyanate | Chain extender | ShoreA/D | Stress(MPa) | Strain(%) | Tg(ºC) |
|---|---|---|---|---|---|---|---|
| R0.95 | PPCDL | HMDI | BDO | 60 | 3.7 | 716 | 21.0 |
| R1.0 | PPCDL | HMDI | BDO | 65 | 4.8 | 645 | 27.0 |
| R1.05 | PPCDL | HMDI | BDO | 95/65 | 22.3 | 191 | 31.9 |
| R1.1 | PPCDL | HMDI | BDO | 95/70 | 31.0 | 50 | 38.0 |
| R1.15 | PPCDL | HMDI | BDO | 98/75 | 42.5 | 28 | 39.5 |
| R1.2 | PPCDL | HMDI | BDO | 98/80 | 47.0 | 15 | 40.0 |

**Table S2.** Preparation of PPCDL-TPU with Different Hard Segments

| Samples | Diol | Isocyanate | Chain extender | ShoreA/D | Stress(MPa) | Strain(%) | Tg(ºC) |
|---|---|---|---|---|---|---|---|
| TPU15% | PPCDL | HMDI | BDO | 65 | 4.1 | 725 | 26.2 |
| TPU20% | PPCDL | HMDI | BDO | 95/65 | 22.3 | 191 | 31.9 |
| TPU25% | PPCDL | HMDI | BDO | 98/72 | 28.0 | 75 | 40.0 |
| TPU30% | PPCDL | HMDI | BDO | 99/74 | 58.0 | 25 | 45.0 |

As shown in Table S1,S2, As the R value and hard segment content increase, the

tensile strength, hardness, and Tg of PPCDL-TPU also increase. However, when R > 1.05, the prepared TPU with a hardness of Shore A95/Shore D65 is difficult to apply. The increase in hard segment content enhances the degree of microphase separation and the number of hydrogen bonds in TPU, providing more physical cross-linking points, thereby improving the mechanical properties of the material.

**Table S3.** Preparation of PPCDL-TPU Using Different Isocyanates

| Samples | Diol | Isocyanate | Chain extender | ShoreA/D | Stress(MPa) | Strain(%) | Tg(°C) |
|---|---|---|---|---|---|---|---|
| MDI-TPU | PPCDL | MDI | BDO | 99/76 | 37.0 | 13 | 38.5 |
| HMDI-TPU | PPCDL | HMDI | BDO | 98/69 | 24.0 | 196 | 39.0 |
| IPDI-TPU | PPCDL | IPDI | BDO | 98/60 | 7.4 | 593 | 29.2 |
| HDI-TPU | PPCDL | HDI | BDO | 90 | 9.2 | 1414 | 20.9 |

As shown in Table S3, The hardness, tensile strength, and Tg of PPCDL-TPU are related to the structure of the diisocyanate used as raw material. Typically, aromatic > alicyclic > aliphatic diisocyanates. The more symmetrical the structure of the diisocyanate, the greater the rigidity of the molecular structure, and the smaller the steric hindrance of the —NCO groups, the higher the hardness, tensile strength, and Tg of the resulting TPU.It is interesting to note that HDI-TPU possesses an outstanding elongation at break of up to 1414%, although its tensile strength is lower than that of HMDI-TPU (24.0MPa) and MDI-TPU (43.0MPa). However, it has a moderate hardness (Shore A 90), and its tensile strength and elongation at break can potentially be improved through modification.

**Table S4.** Preparation of PPCDL-PEG-TPU with different molecular weights of PEG

| Samples | Diol | Isocyanate | Chain extender | ShoreA/D | Stress(MPa) | Strain(%) | Tg(°C) |
|---|---|---|---|---|---|---|---|
| TPU600 | PPCDL/PEG600 | HDI | BDO | 85 | 4.7 | 950 | 16.0 |
| TPU1000 | PPCDL/PEG1000 | HDI | BDO | 83 | 25.6 | 2094 | 23.0 |
| TPU2000 | PPCDL/PEG2000 | HDI | BDO | 80 | 9.3 | 1783 | 16.5 |

In summary, PPCDL-TPUs prepared using single PPCDL as the soft segment exhibit greater hardness, higher tensile strength, and lower elongation at break. To optimize cost control, all experiments utilized a fixed R-value of 1.05, maintained a hard segment composition of 20%, and employed BDO as the chain extender. As shown in Table S4, When using HDI as a raw material, the prepared PPCDL-TPU has good tensile strength, but the hardness is higher. It is exciting that upon introducing polyether PEG into its soft segments, the addition of PEG1000 not only enhances the elongation at break and tensile strength but also reduces its hardness.

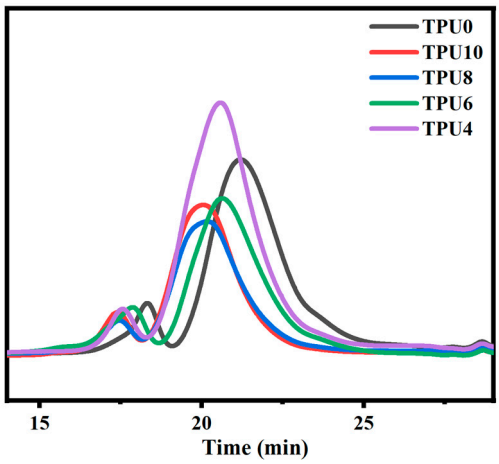



**Figure S1.** GPC curves of the prepared TPUs

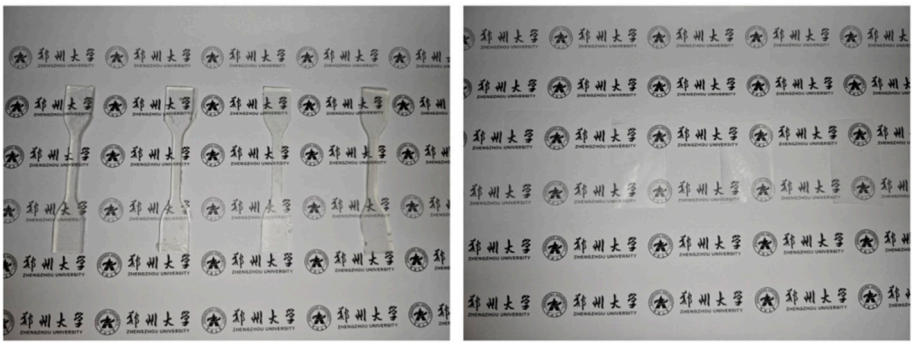
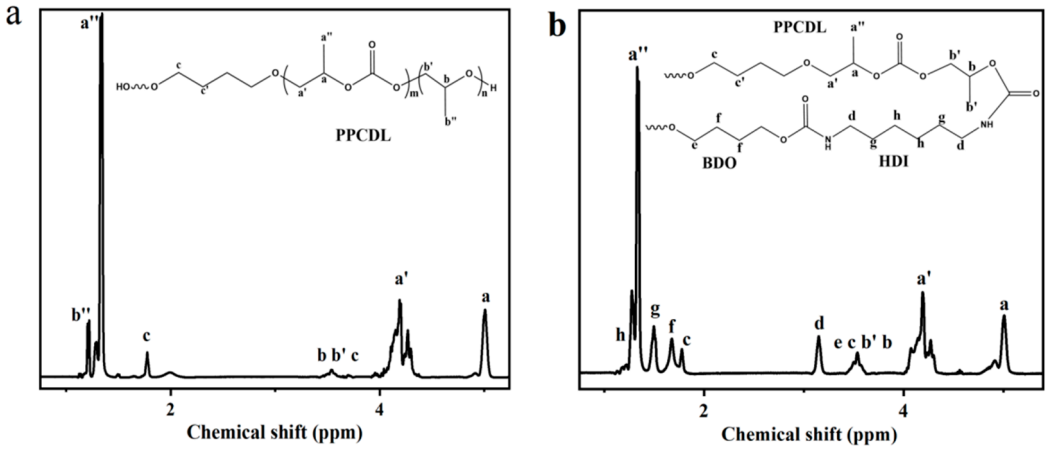


**Figure S2.** PPCDL-PEG$_{1000}$-TPUs' film and profile appearance



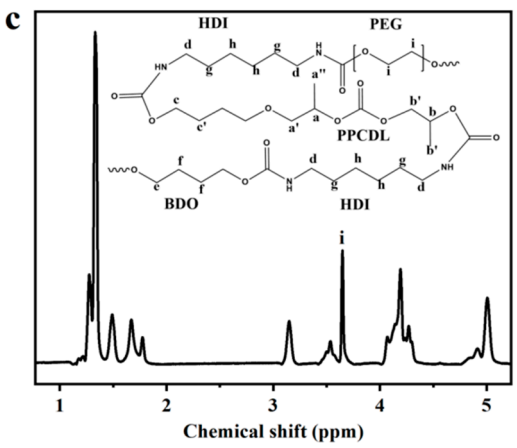



**Figure S3.** (a) $^{1}$H-NMR spectrum of purified PPCDL , (b) $^{1}$H-NMR spectrum ofTPU0, (c) $^{1}$H-NMR spectrum of TPU10



**Figure S4.** Deformation of PPCDL-PEG$_{1000}$-TPUfilm during tensile process.

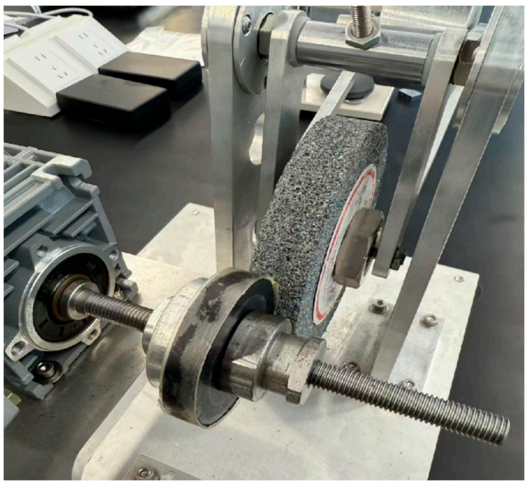


**Figure S5.** PPCDL-PEG$_{1000}$-TPU Wear Resistance Test.