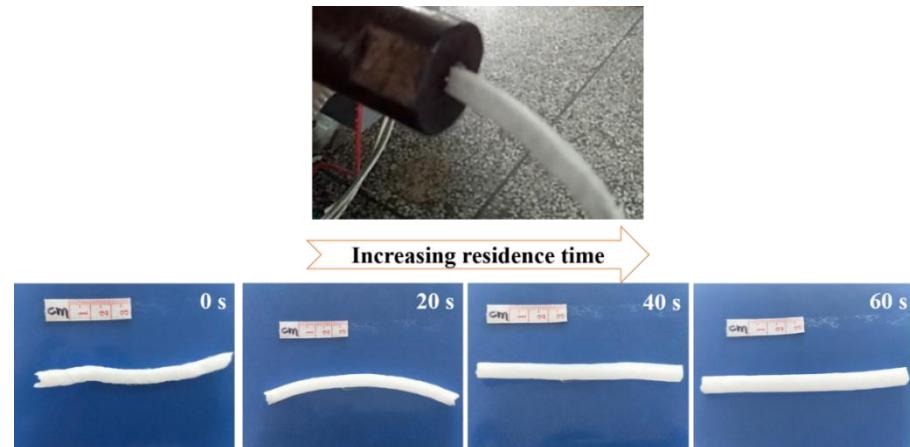
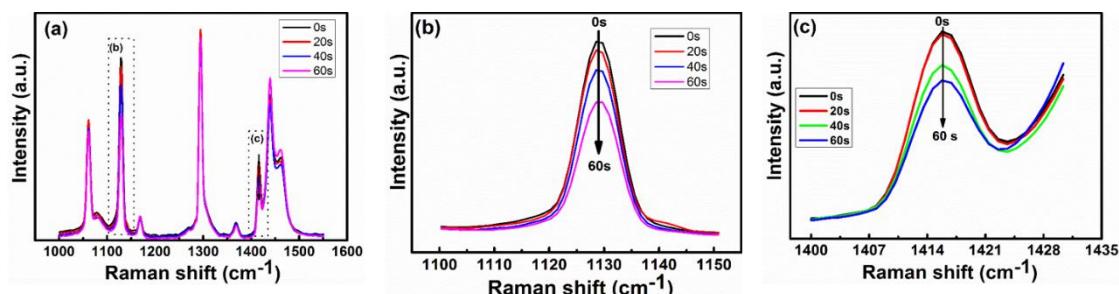


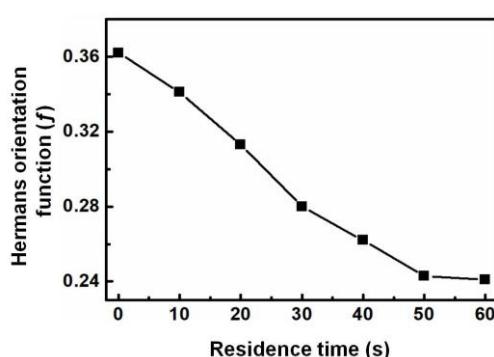
**Figure S1.** Eccentric rotor extruder



**Figure S2.** Photograph of UHMWPE samples under elongation flow samples at 180 °C with 0s.20s.40s.60s residence time.



**Figure S3.** Raman spectra of the UHMWPE sample under a consecutive elongational flow with 0s.20s.40s.60s residence time.



**Figure S4.** Hermans orientation function (*f*) of the UHMWPE samples at surface under a consecutive elongational flow from 0 to 60s seconds residence time.

**Table S1.** DSC analysis result of the UHMWPE nascent powder and the UHMWPE sample produced at 180 °C with different residence time.

Sample	T <sub>m1</sub> (°C)	ΔH <sub>m1</sub> (J/g)	X <sub>c1</sub> (%)	T <sub>m2</sub> (°C)	ΔH <sub>m2</sub> (J/g)	X <sub>c2</sub> (%)	T <sub>c</sub> (°C)
Nascent powder [1]	143.2	185.9	64.1	136.0	137.0	47.2	116.7
0 s	137.5	128.4	44.3	131.2	131.2	45.2	116.86
20 s	139.2	118.5	40.9	138.5	118.6	40.9	116.21
40 s	139.23	113.5	39.2	139.6	116.4	40.1	114.7
60 s	139.1	94.67	32.6	139.5	96.4	33.2	115.32

Note: “1” and “2” stand for the first heating run and the second heating run respectively.

[1]: The data is adopted from Ref. 1.

**Table S2.** Assignments of the main Raman bands of UHMWPE in the v(C-C), τ(CH<sub>2</sub>) and δ(CH<sub>2</sub>) ranges (indicated as region I, II and III, respectively), adopted from Ref. 2

Raman shift(cm <sup>-1</sup> )	Mode	Phase
1060	v <sub>as</sub> (C-C)	Crystalline + amorphous trans
1080	v(C-C)	Amorphous gauche
1130	v <sub>s</sub> (C-C)	Crystalline + amorphous trans
1170	v <sub>p</sub> (CH <sub>2</sub> )	Crystalline + amorphous trans
1295	τ(CH <sub>2</sub> )	Crystalline
1305	τ(CH <sub>2</sub> )	Amorphous gauche
1416	δ(CH <sub>2</sub> )	Crystalline
1440	δ(CH <sub>2</sub> )	Amorphous trans (interphase)
	Fermi resonance	
1460	δ(CH <sub>2</sub> )	Amorphous
2848	v <sub>s</sub> (CH <sub>2</sub> )	
2881	v <sub>as</sub> (CH <sub>2</sub> )	

δ = bending ; τ = twisting ; v = stretching ;

$\rho$  = rocking ; s = symmetric ; as = antisymmetric.

Note: the data in Tab. S2 is adopted from Ref. 2.

**Table S3.** Raman and DSC analysis results of the UHMWPE samples prepared at 180 °C with different residence time.

Sample (s)	DSC-X <sub>c1</sub> (%)	Raman- $\alpha_c$ (%)	Raman- $\alpha_b$ (%)	Raman- $\alpha_a$ (%)
0	45.2	42.18	23.44	34.4
20	40.9	39.9	28.2	31.9
40	40.1	36.6	27.5	35.9
60	33.2	31.8	28.1	41.2

**Table S4.** Kinetics values for the UHMWPE chain diffusion according to the reptation theory

Mw(g/mol)	$\tau_1$	N	Ne	trep	Rg	t(x=Rg)
$1.0 \times 10^6$	$1.0 \times 10^{-10}$	$3.57 \times 10^4$	89.0	$5.12 \times 10^1$	$2.08 \times 10^{-7}$	$5.12 \times 10^1$
$2.0 \times 10^6$	$1.0 \times 10^{-10}$	$7.14 \times 10^4$	89.0	$4.09 \times 10^2$	$2.94 \times 10^{-7}$	$4.09 \times 10^2$
$3.0 \times 10^6$	$1.0 \times 10^{-10}$	$1.07 \times 10^4$	89.0	$1.38 \times 10^3$	$3.60 \times 10^{-7}$	$1.38 \times 10^3$
$4.0 \times 10^6$	$1.0 \times 10^{-10}$	$1.43 \times 10^4$	89.0	$3.28 \times 10^3$	$4.16 \times 10^{-7}$	$3.28 \times 10^3$
$5.0 \times 10^6$	$1.0 \times 10^{-10}$	$1.79 \times 10^4$	89.0	$6.40 \times 10^3$	$4.65 \times 10^{-7}$	$6.40 \times 10^3$
$6.0 \times 10^6$	$1.0 \times 10^{-10}$	$2.14 \times 10^4$	89.0	$1.11 \times 10^4$	$5.09 \times 10^{-7}$	$1.11 \times 10^4$
$7.0 \times 10^6$	$1.0 \times 10^{-10}$	$2.50 \times 10^4$	89.0	$1.76 \times 10^4$	$5.50 \times 10^{-7}$	$1.76 \times 10^4$
$9.0 \times 10^6$	$1.0 \times 10^{-10}$	$2.80 \times 10^4$	89.0	$2.47 \times 10^4$	$5.82 \times 10^{-7}$	$2.47 \times 10^4$

Note: N is the number of monomer units per chain; Ne is the number of monomer units between entanglements;  $\tau_1$  is the microscopic time of monomer motion.

## References

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2. Pezzotti, G. Raman spectroscopy of biomedical polyethylenes. *Acta Biomater.* **2017**, *55*, 28-99.