Supplementary Information

Upcycled waxes from mixed polyolefins for hot-melt adhesives (HMA) applications

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Characterization and Instruments

Differential scanning calorimetry (DSC) was conducted with a Q100 Analyzer (TA Instruments). Samples with weights in the range of 5-10 mg were used for each test. All DSC analyses were performed under nitrogen at a heating ramp of 10 ºC/min via heat-cool-heat cycles. The samples were equilibrized at -20 ºC and then heated to 220 ºC. The first heating cycle was performed to remove the polymer's thermal history. The second cooling cycle and third heating cycle were used for data acquisition.

Thermogravimetric analysis (TGA) analyses of the HMA samples were performed with a TA Q50 system (TA Instruments). All the samples with weights in the range of 5-10 mg were characterized at a heating rate of 10 ºC/min from 25 to 600 ºC under nitrogen. The average values of two TGA and DSC measurements are reported in this article.

Nuclear magnetic resonance (NMR) analysis was conducted with a 500 MHz NMR spectrophotometer. The chemical shifts δ were recorded in ppm. A deuterated solvent ($CDCl_3$) was used, which was also used as an internal reference.

Methodology of Testing the efficacy and sealing strength of the adhesive sealing

Thermal sealing qualities were investigated using a bar sealer (SENCORP, MA, USA) by the ASTM F88/F88M-21 methodology.[1] The average and maximum seal strengths were measured. Sealed specimens were created which were 1 inch wide and 4 inches long. The samples were sealed at a temperature of 392 °F (200 °C) for 5 seconds at a pressure of 35 psi. The seal width was fixed at 0.4 inches. Five replicate measurements were recorded for each sample. Before the seal strength tests, the produced sealed samples were held at 50% RH and 25 °C for 6 h, 12 h, 24 h, 48 h, and 1 week. The seal strength was measured with a 5565 Universal Instron Testing Machine using an initial grip separation distance of 1 inch. The force required to break the seal was measured in newtons (N).

Figure S1. Photographs taken during the wax recovery process that was performed via hot water dispersion.

^{1}H-NMR Spectrum

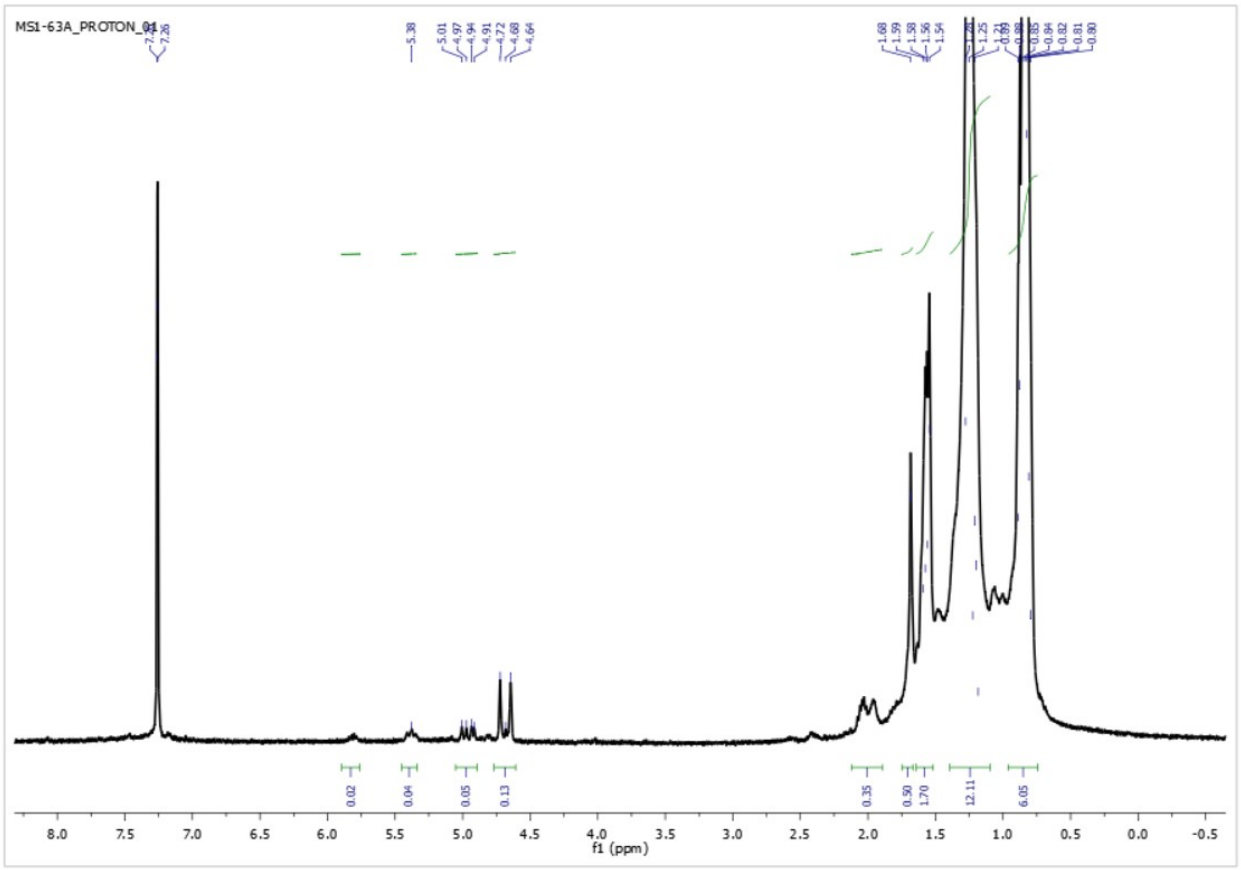

Figure S2. ^{1}H-NMR spectrum of Wax A.

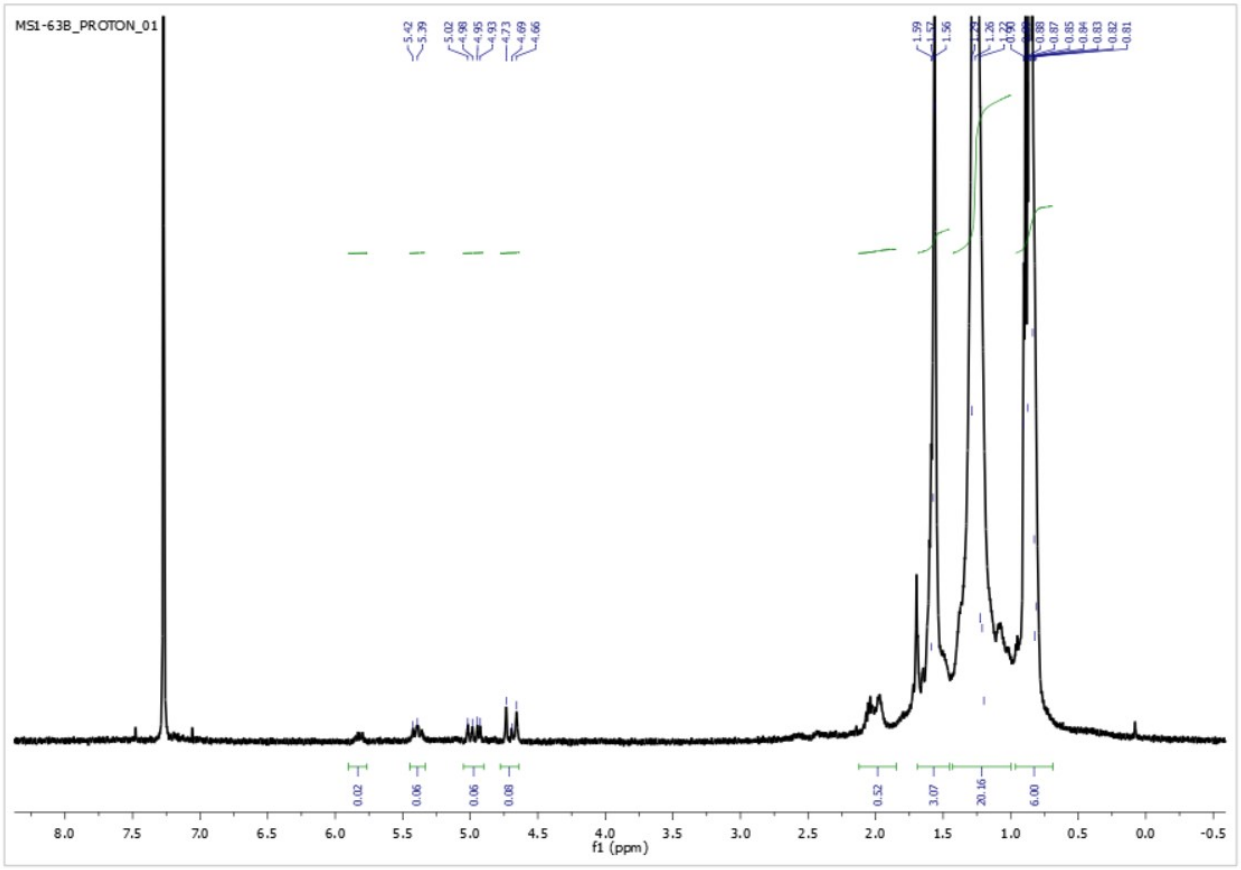

Figure S3. ^{1}H-NMR spectrum of Wax B.

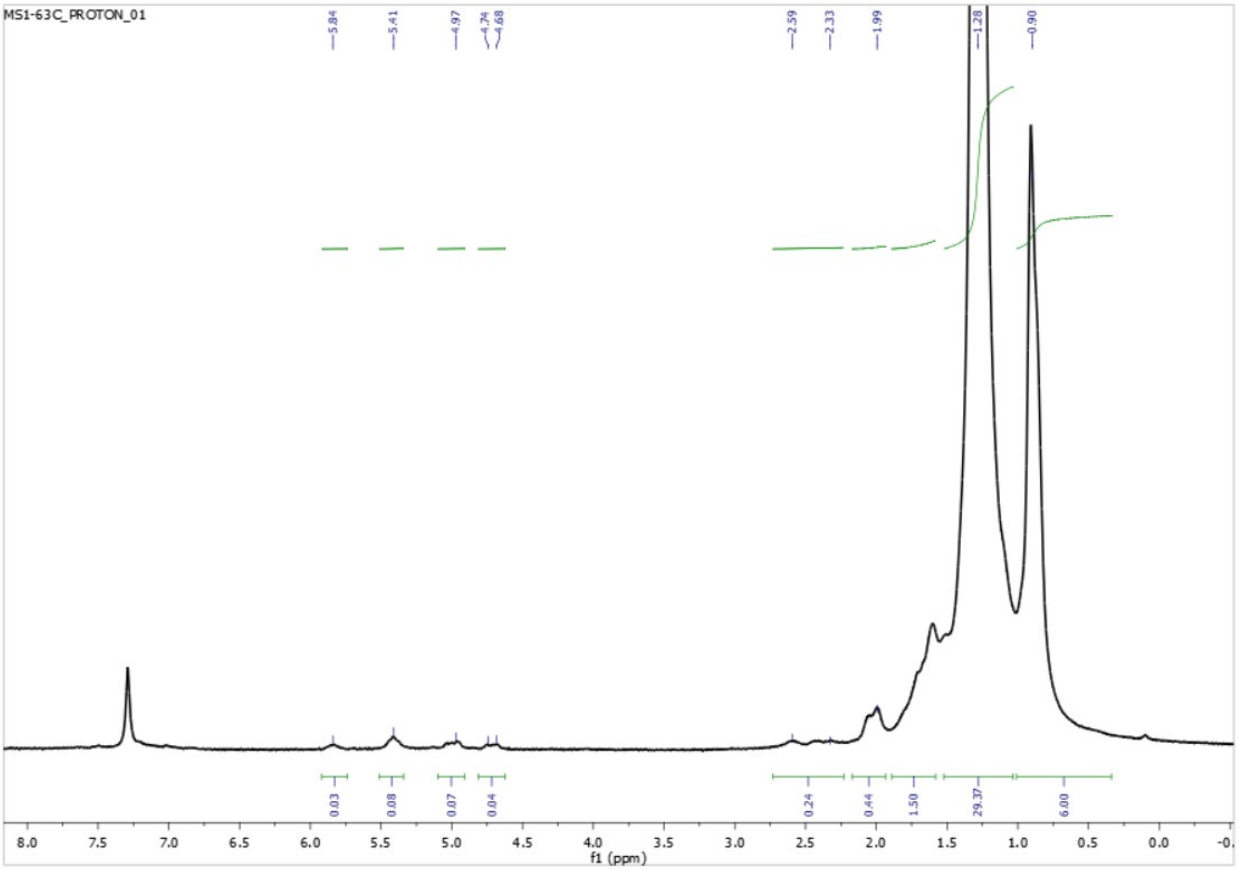

Figure S4. ^{1}H-NMR spectrum of Wax C.

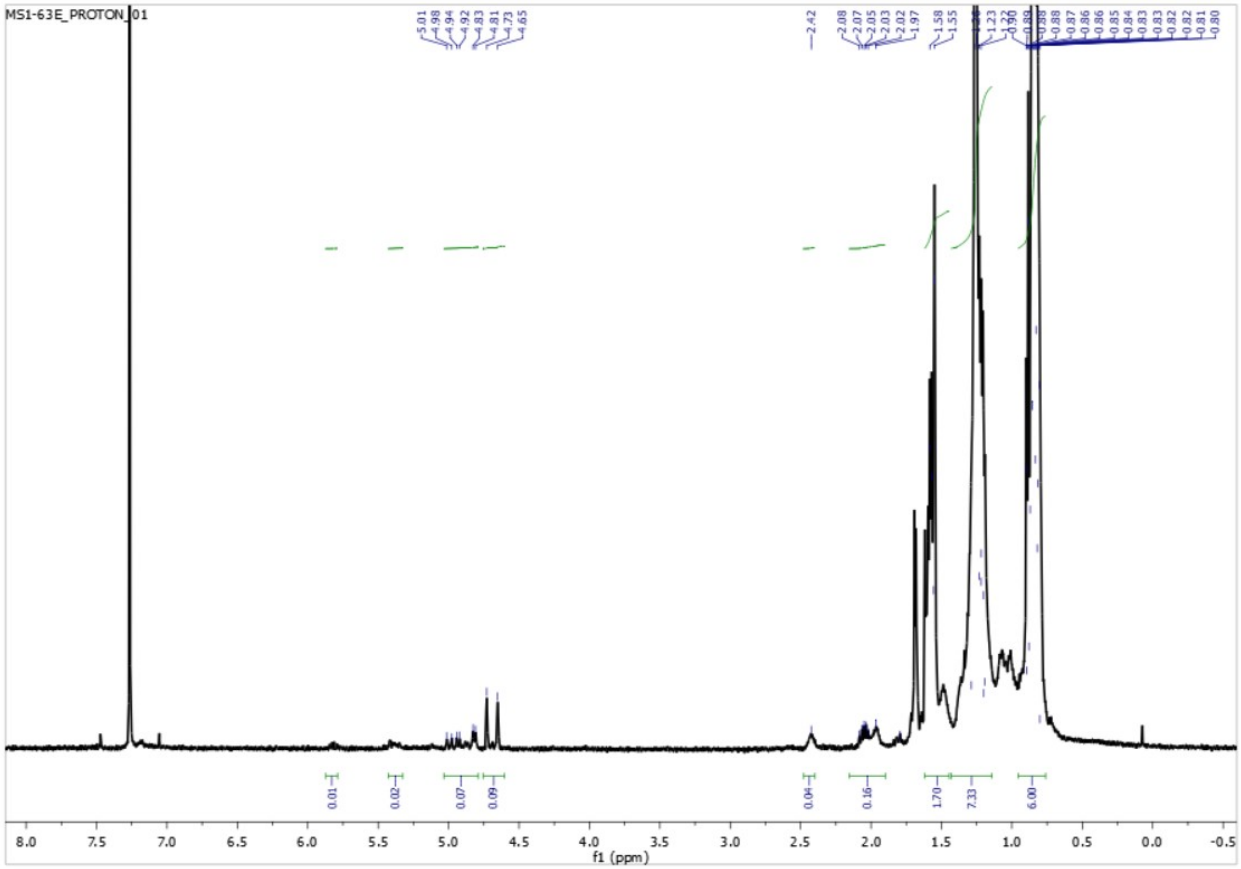

Figure S5. ^{1}H-NMR spectrum of Wax E.

GC-MS analysis

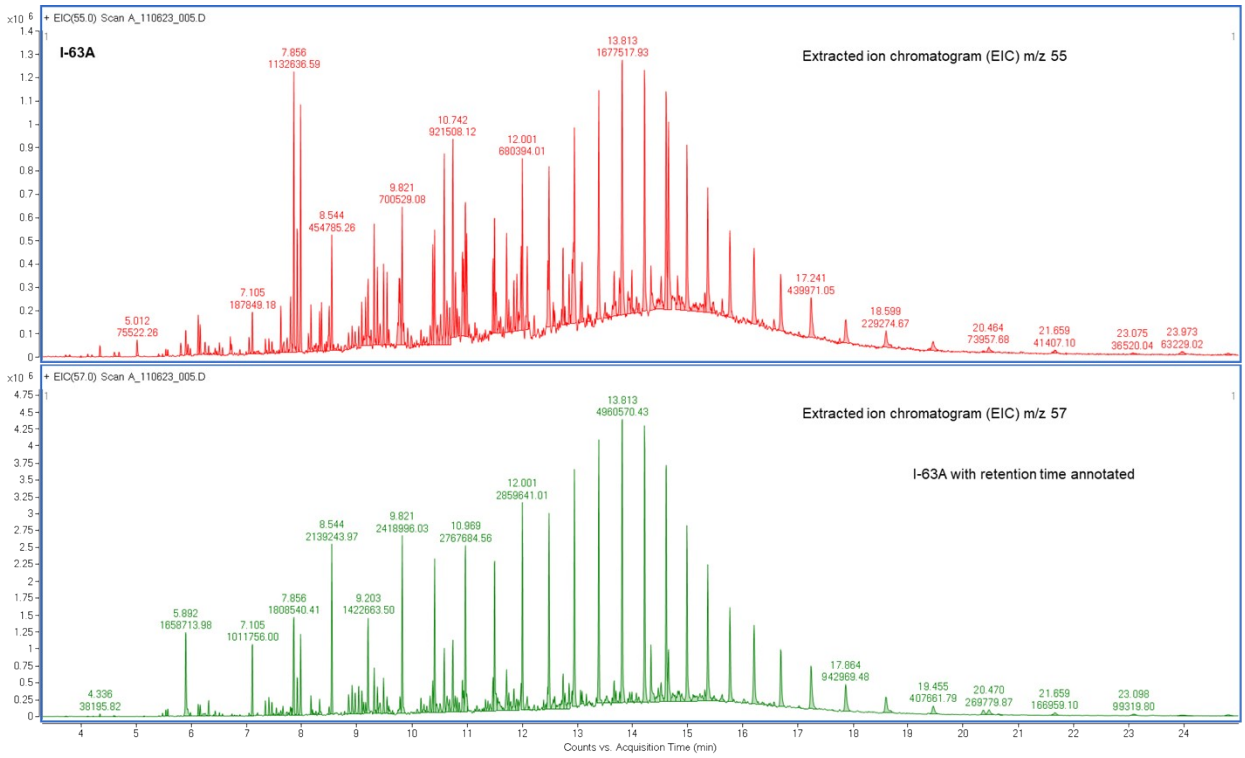

Figure S6. GC-MS pattern of Wax A.

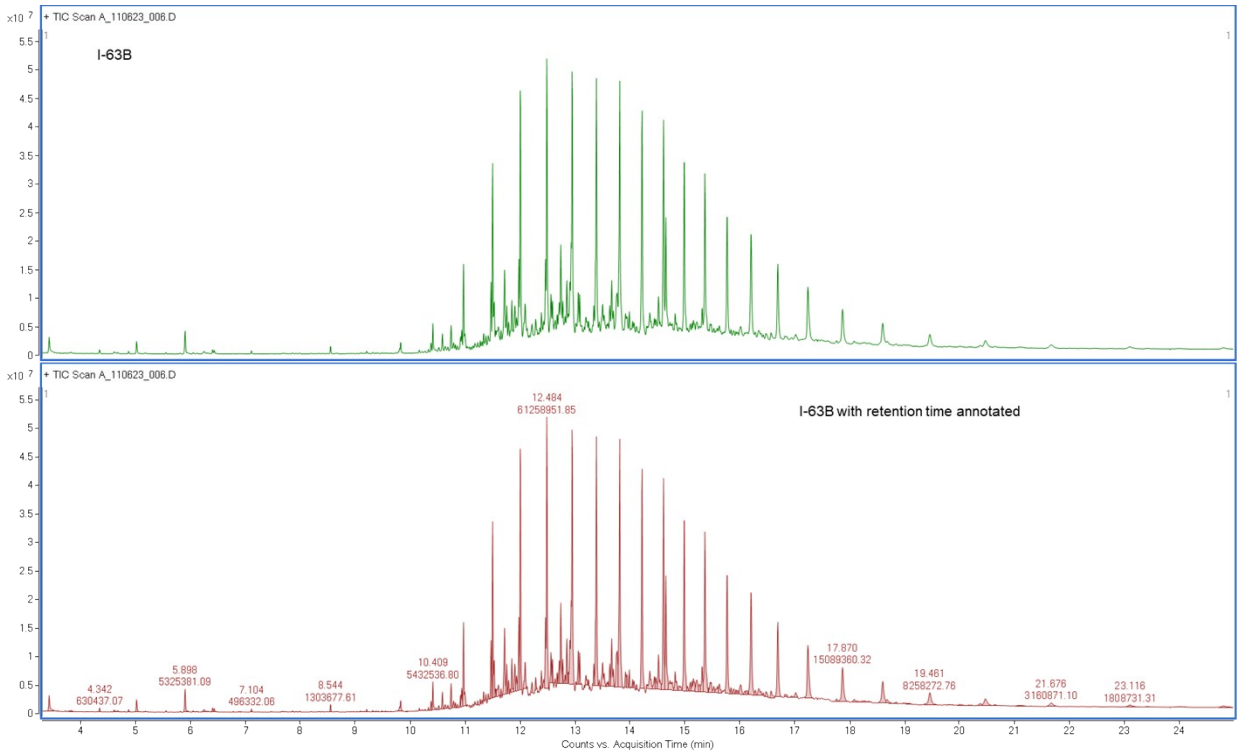

Figure S7. GC-MS pattern of Wax B.

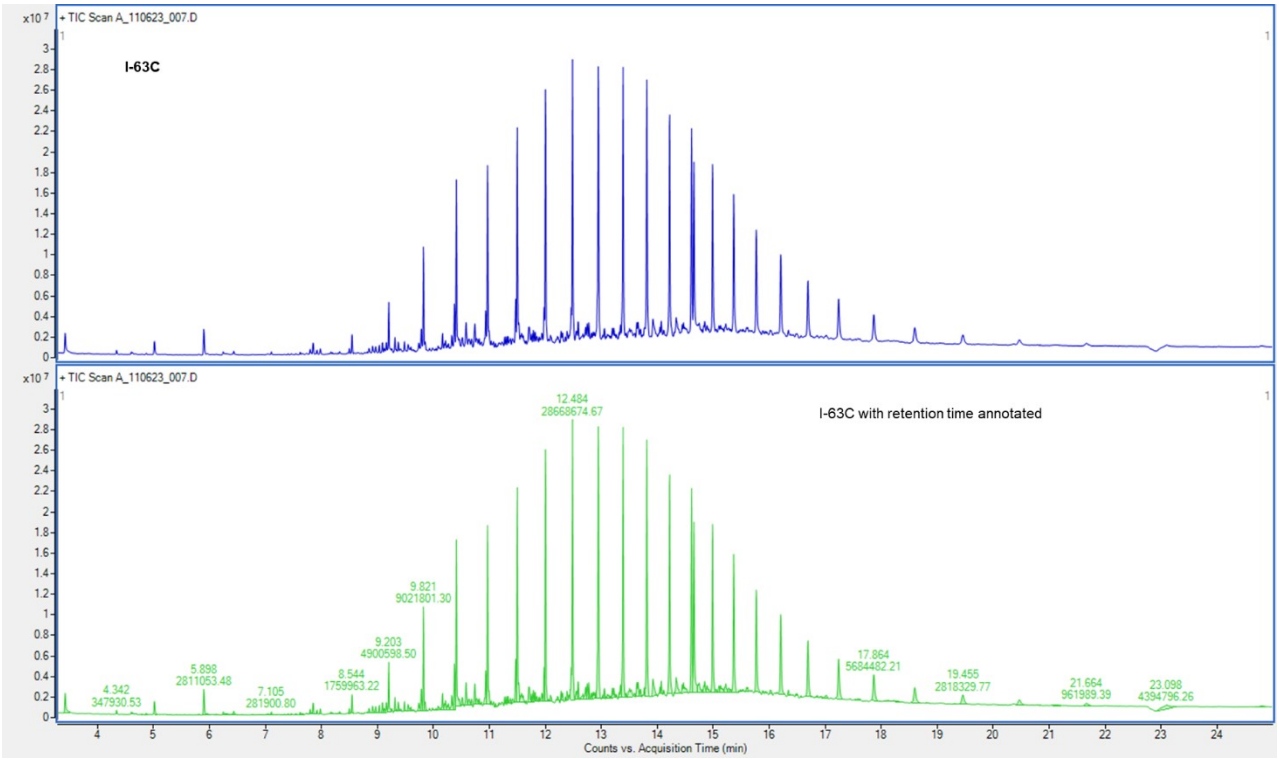

Figure S8. GC-MS pattern of Wax C.

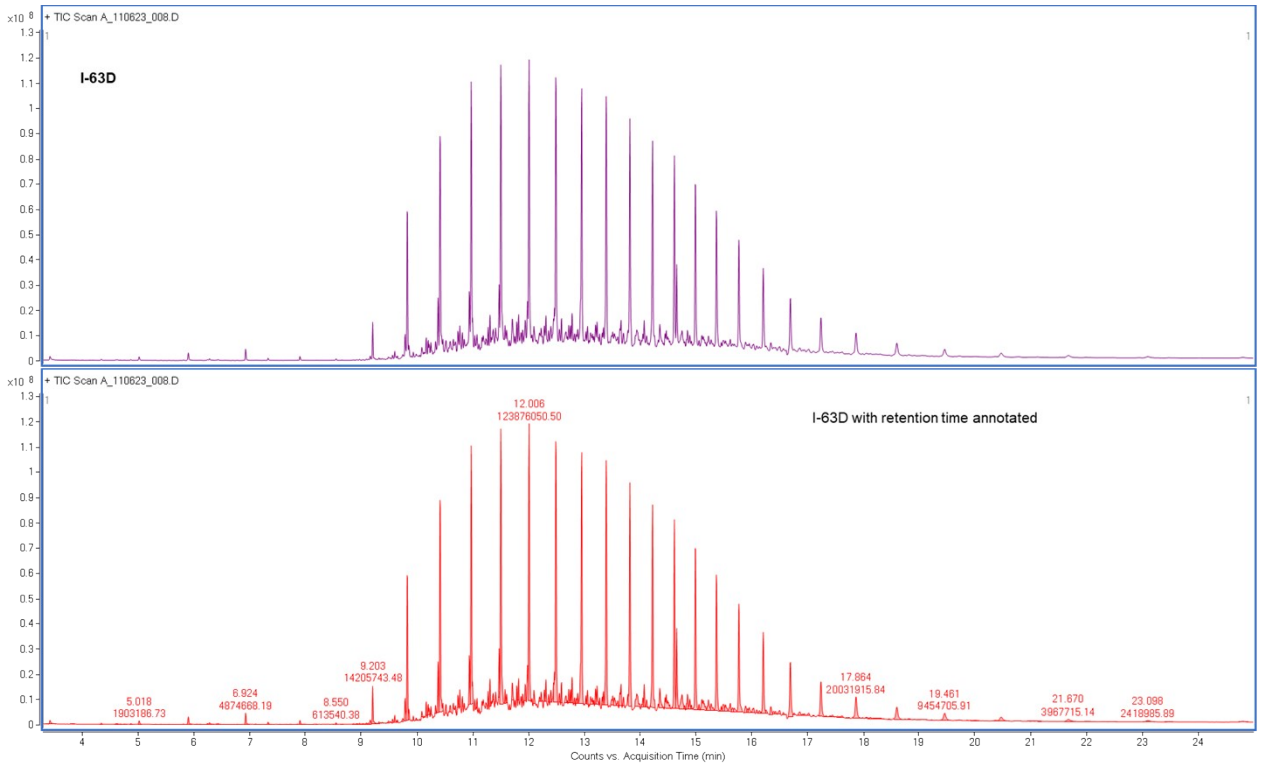

Figure S9. GC-MS pattern of Wax D.

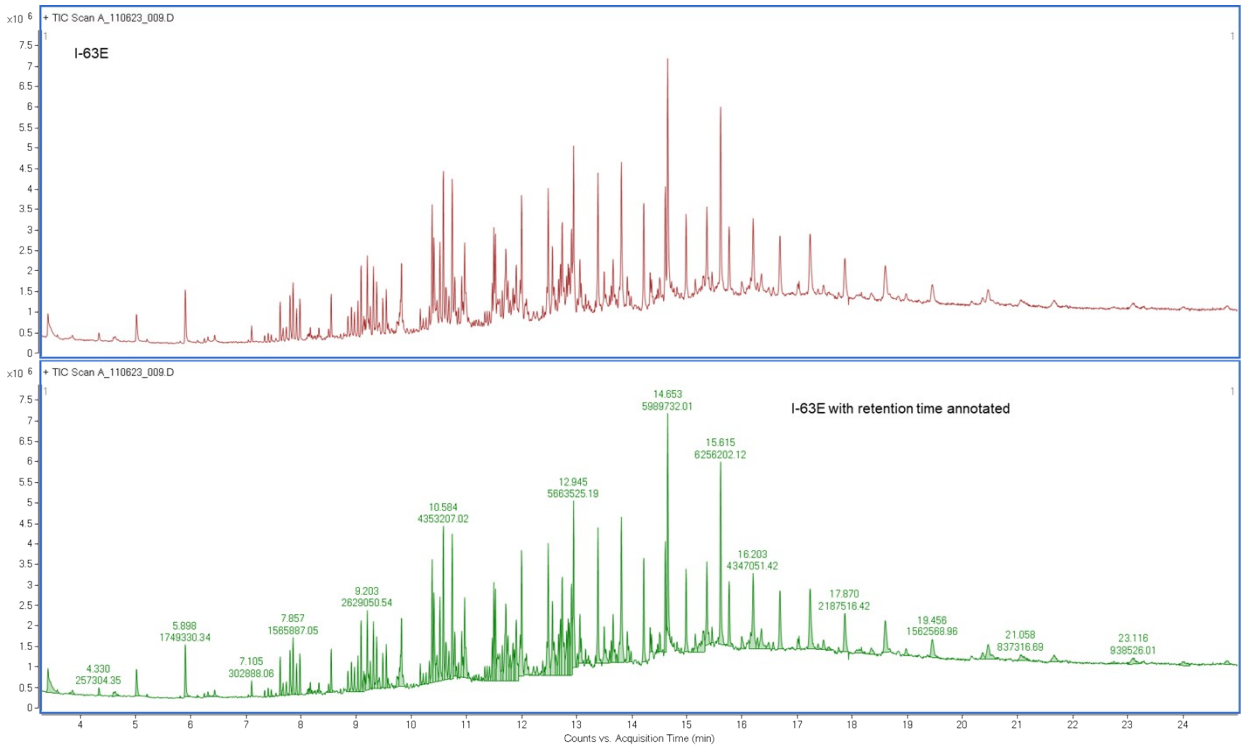

Figure S10. GC-MS pattern of Wax E.

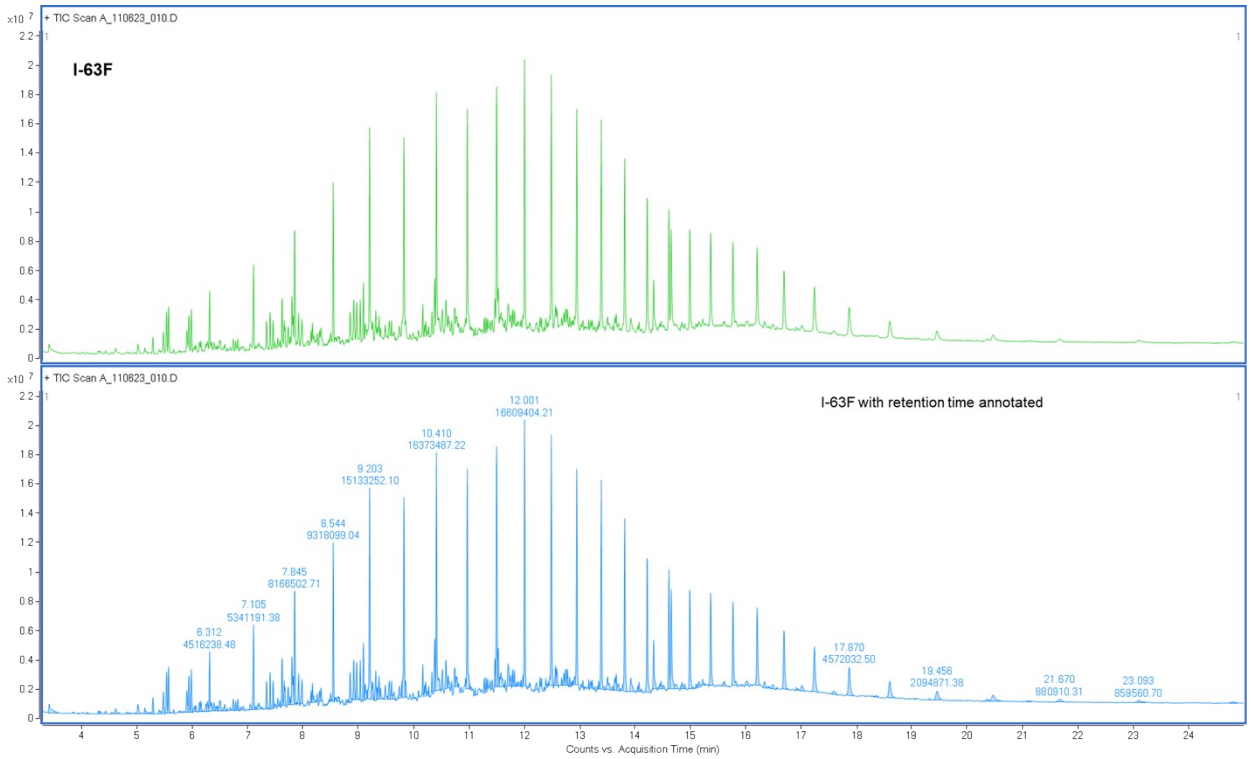

Figure S11. GC-MS pattern of Wax F.

Table S1. Comparison between Lab-made HMA (LHMA) and Commercial HMA (CHMA).

Properties	**Commercial Glue Gun Stick**	**The Stick made in our lab (Mixed Waste Plastic Wax)**
Shape	Thick and consistent	Consistent and elastic
Flow	Viscous	Less viscous than the commercial counterpart
Set Time	3 s	5 s
Odor	Less Odor	More Odor (this can be overcome by removing volatile compounds before recycled waxes)
Tackiness	Highly Sticky	Highly Sticky

Table S2. Comparison of strength and force required to peel the adhesion of commercial-grade HMA (CHMA) and lab-made HMA (LHMA).

Sealing Peel Force (N)		
Adhesion time	Commercial HMA (CHMA)	LAB HMA (LHMA)
	Average	Average
6 h	8.48±0.28	9.64±0.80
12 h	12.5±0.13	10.35±0.65
24 h	10.44±0.23	9.42±0.60
48 h	9.64±0.10	16.75±1.41
1 week	15.9±0.60	14.69±0.50
Seal Peel Strength (lbf)		
Adhesion time	Commercial HMA (CHMA)	LAB HMA (LHMA)
	Average	Average
6 h	1.91±0.06	2.17±0.18
12 h	2.81±0.03	2.33±0.15
24 h	2.35±0.05	2.21±0.14
48 h	2.17±0.02	3.77±0.32
1 week	3.58±0.14	3.3±0.10

References:

1. COMPASS, A., Standard Test Method for Seal Strength of Flexible Barrier Materials https://compass.astm.org/document/?contentCode=ASTM%7CF0088_F0088M-21%7Cen-US&proxycl=https%3A%2F%2Fsecure.astm.org&fromLogin=true. 2023.