Supplementary Material

Supplementary Table 1. Descriptive statistics of material waste by lens type. Data represent the percentage of mass loss across 12 experimental groups (n=187). Values are presented as mean (Average %), median, and standard error of the mean (SEM). FOT and HC denote specific material or processing variants.

Type of Lenses	n	Average(%)	Median (%)	SEM
min 1.5	7	50,649	53,565	4,651
min. 1.5 FOT	11	51,282	52,948	4,014
min. 1.6	4	39,716	38,523	1,911
min 1.7	2	62,806	62,806	2,072
1.5	59	50,153	48,135	1,361
1.5 FOT	20	47,191	47,850	2,205
1.56 HC	4	42,376	41,284	1,378
1.6	53	51,305	53,472	2,152
1.6 FOT	2	50,806	50,806	2,591
1.67	19	64,201	72,509	4,884
1.67 FOT	2	49,163	49,163	7,105
1.74	4	32,832	29,820	9,949

Supplementary Table 2. Results of the single-factor analysis of variance (ANOVA) for percentage mass loss for the 12 lens groups analysed.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6062,2998	11	551,118164	2,90794388	0,00151844	1,84370828
Within Groups	33166,2792	175	189,521595			
Total	39228,579	186				

The table shows the overall comparison between the 12 lens groups analysed (n=187). The F value (2.908) greater than the F critical value (1.843), together with a p-value of 0.0015 indicates that there are statistically significant differences between the mean mass loss values of the groups at a 95% confidence level.
SS: sum of squares; df: degrees of freedom; MS: mean square.

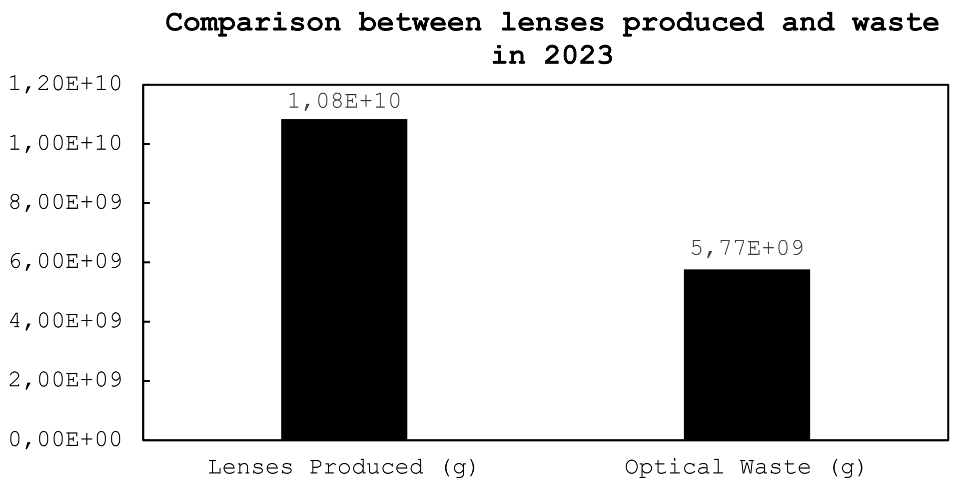
Supplementary Table 3. Pairwise comparisons between refractive index categories using Student's t-test.

Paired Comparisons	*t Stat*	*P(T≤t) one-tail*	*P(T≤t) two-tail*	*t Critical two-tail*	*Result*
Low Index vs. Medium Index	-0,285	0,388	0,776	1,983	No Significance
Medium Index vs. High Index	-1,662	0,053	0,106	2,032	No Significance
Low Index vs. High Index	-1,888	0,035	0,069	2,048	No Significance

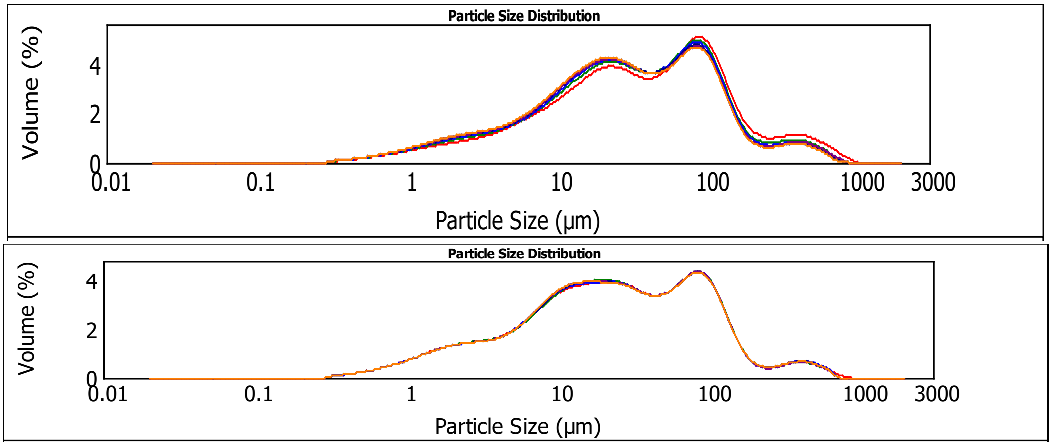
The lenses samples were grouped into three macro categories of refractive indices: Low Index (1.50), Medium Index (1.56-1.60) and High Index (1.67-1.74). Student's t-test was applied to two categories assuming unequal variances (Welch's test). The results show that, despite the trends observed, the differences between the index categories did not reach statistical significance (p>0.05), suggesting that waste is transversal across all ranges of materials.

Supplementary Table 4. Results of the single-factor analysis of variance (ANOVA) for percentage mass loss grouped into three macro categories of refractive indices.

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1679,86554	2	839,93277	4,11592344	0,01783646	3,04503999
Within Groups	37548,7135	184	204,069095			
Total	39228,579	186				



Supplementary Fig.1. Comparison between the total lenses produced and the resulting ophthalmic waste in 2023.



Supplementary Fig.2. Particle size distribution of lens-grinding waste before and after undergoing ultrasound treatment obtained using laser diffraction. Each curve represents a different measurement for the specified condition.

Supplementary Table 5. Particle size distribution parameters (span and characteristic diameters) of lens-grinding waste, determined by laser diffraction using the Fraunhofer approximation. Values represent the average of multiple measurements.

	D[3,2]µm	**D[4,3]µm**	**d[0.9]µm**	**d[0.5]µm**	**d[0.1]µm**	**span**

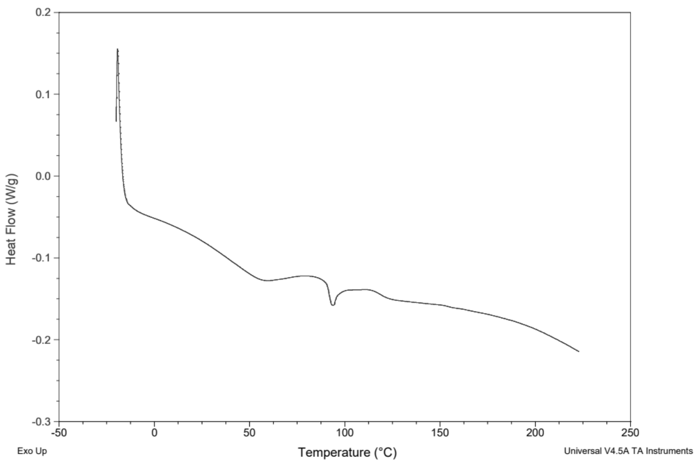
Lens-grinding waste	9.14 (±0.48)	70.52 (±7.94)	153.03 (±20.65)	33.38 (±3.16)	4.02 (±0.33)	4.45 (±0.18)
Lens-grinding waste after submitting to ultrasounds	7.119 (±0.008)	53.260 (±0.897)	118.286 (±0.953)	23.530 (±0.121)	2.730 (±0.008)	4.911 (±0.018)

Supplementary Table 6. Quantification of heavy metals in ophthalmic waste by atomic absorption spectroscopy.

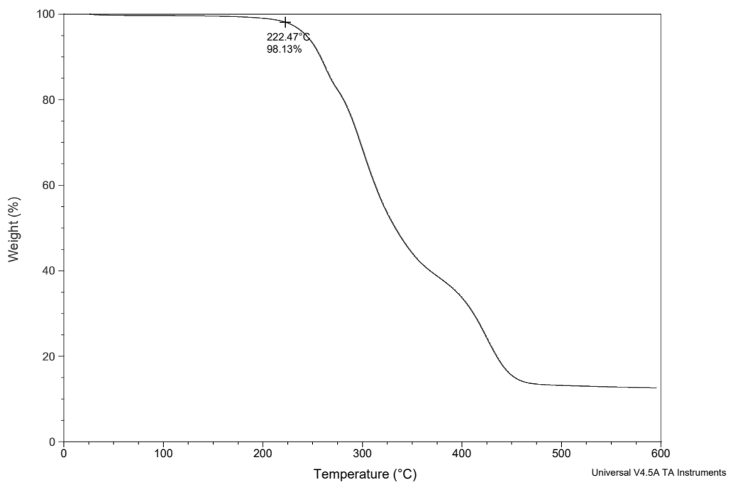
Sample	mg Cu/g	mg Cd/g	mg Cr/g	mg Pb/g
Ophthalmic waste	0.0069	≤0.0001	0.0063	0.0116

Supplementary Table 7. Elemental analysis by EDS of ophthalmic residues of edging lenses.

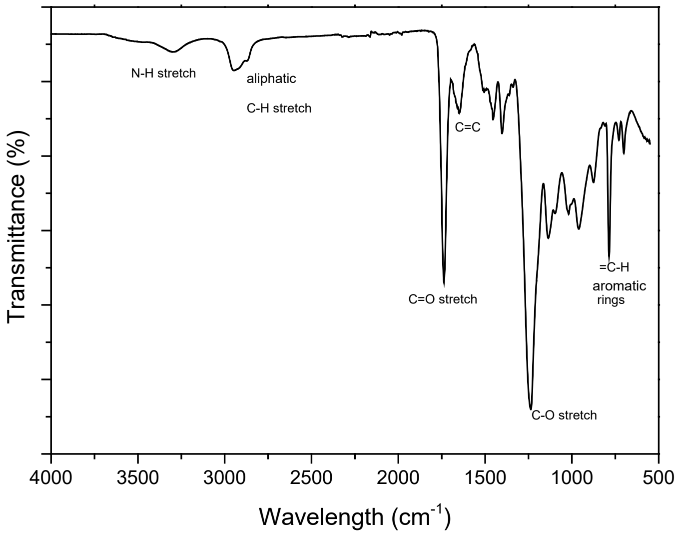
Element	Normalized Content (wt. %)	Error (wt. %)
Carbon	59.17	16.27
Nitrogen	9.13	4.53
Oxygen	11.66	4.26
Silicon	0.36	0.12
Sulfur	19.68	1.49



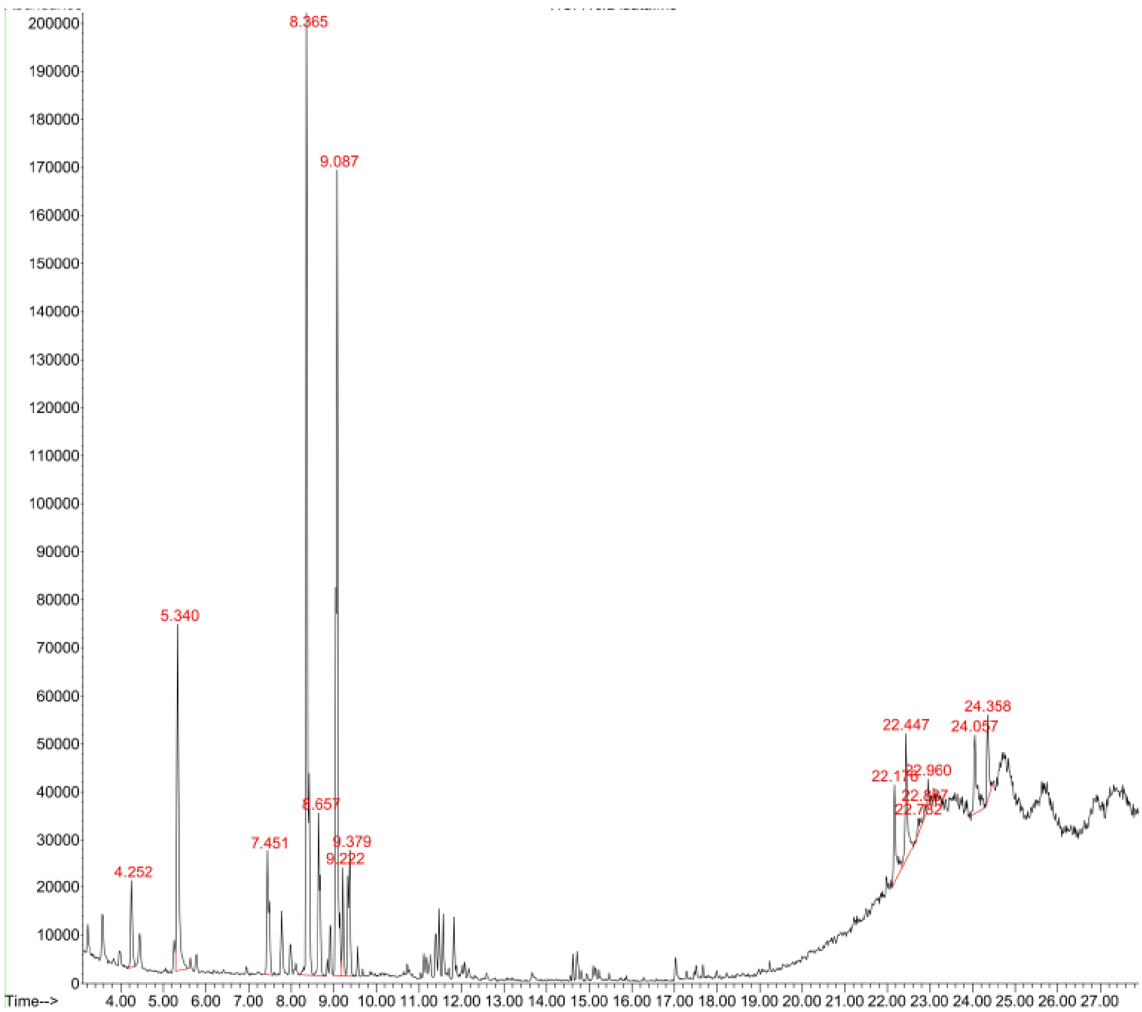
Supplementary Fig. 3. Differential scanning calorimetry characterisation of lens-grinding waste.



Supplementary Fig. 4. TGA characterisation of lens-grinding waste.



Supplementary Fig. 5. FTIR characterisation of lens waste.

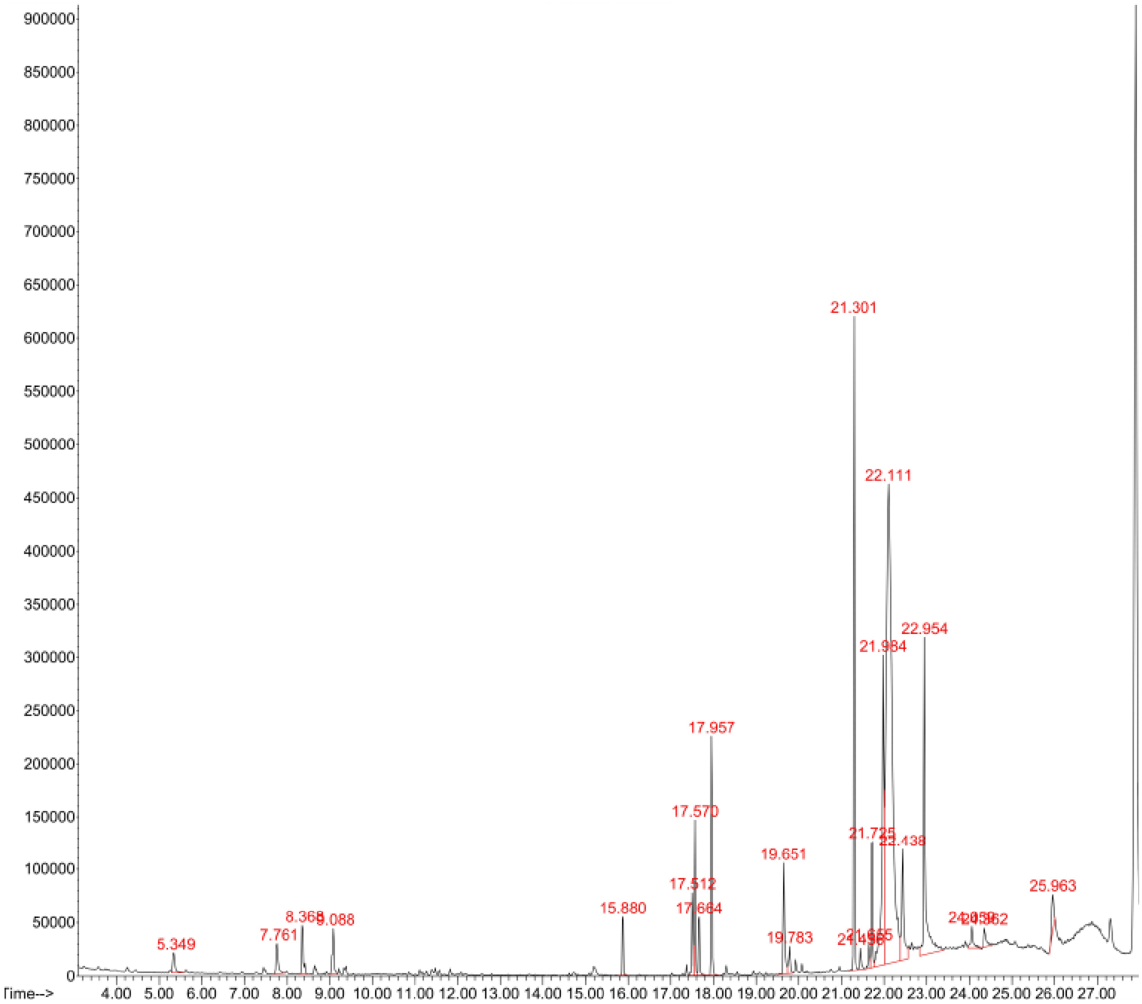


Supplementary Fig. 6. GC-MS chromatogram of the ophthalmic lens wastewater obtained in the final stage of 187 eyeglass lens grinding.

Supplementary Table 8. Compounds identified by GC-MS in ophthalmic wastewater.

Retention time	Name of Compound	MW in g/mol	Formula	% Similarity
4.252	Formyl pyruvyl urea	158.11	$C_5H_6N_2O_4$	64
5.340	4-methyl-2-pentanol	102.17	$C_6H_{14}O$	59
7.471	2,4-dimethyl-3-hexene	112.21	C_8H_{16}	43
8.365	Trans-2-pentenal	84.12	C_5H_8O	64
8.657	Diisoamyl ether	158.28	$C_{10}H_{22}O$	64
9.087	1-Methyl-2-propylcyclohexane	140.27	$C_{10}H_{20}$	80
9.222	3,3,4-trimethyl-hexane	128.25	C_9H_{20}	53
9.379	3-ethyl-3-heptanol	144.25	$C_9H_{20}O$	38
22.176	Heptadecyl pentafluoropropionate	402.49	$C_{20}H_{35}F_5O_2$	76
22.447	2-(methoxymethyl)-1,1,3,3-tetramethyl-1,3-disilacyclohexane	216.47	$C_{10}H_{23}OSi_2$	72
22.782	Sulfurous acid, butyl octadecyl ester	390.7	$C_{22}H_{46}O_3S$	83
22.887	Nonahexacontanoic acid	999.83	$C_{69}H_{138}O_2$	76
22.960	Nonahexacontanoic acid	999.83	$C_{69}H_{138}O_2$	64

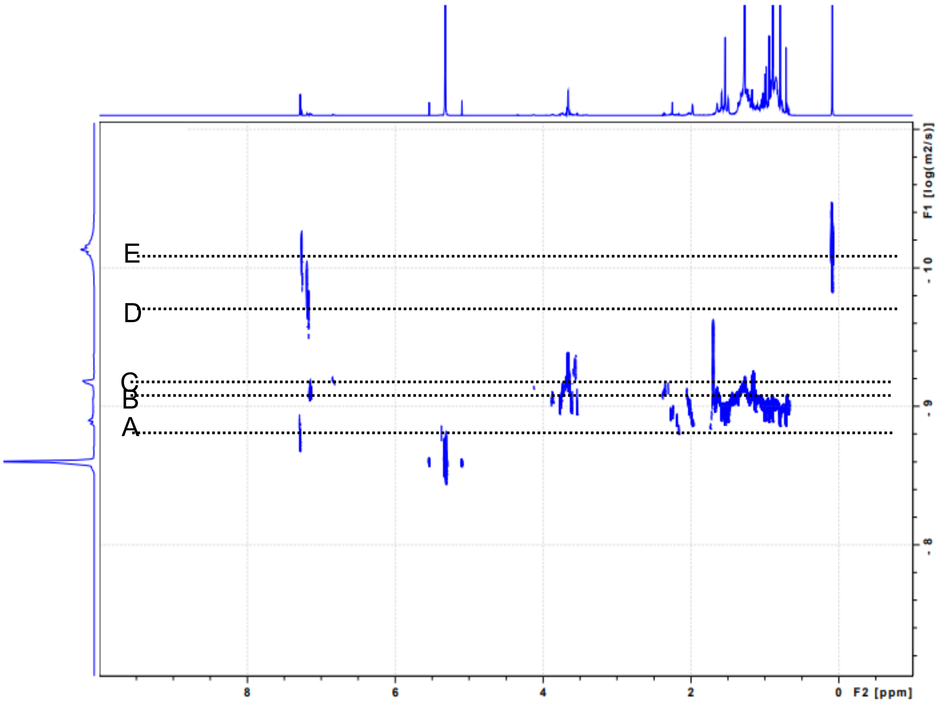
24.057	HAHNFETT Phytol acetate	--- 338.57	--- $C_{69}H_{138}O_2$	81 72
24.358	Heptadecyl heptafluorobutyrate	452.5	$C_{21}H_{35}F_7O_2$	76



Supplementary Fig. 7. GS-MS chromatogram represents the analysis of the solid ophthalmic waste in the final stage of 187 eyeglass lens grinding.

Supplementary Table 9. Compounds identified by GC-MS in solid ophthalmic waste.

Retention time	Name of Compound	MW in g/mol	Formula	% Similarity
5.349	2-Hexanol	102.17	$C_6H_{14}O$	59
7.761	Styrene	104.15	C_8H_8	95
8.368	3,4-Dihydropyran	84.12	C_5H_8O	59
9.088	Sulfurous acid, cyclohexylmethyl pentadecyl ester	388.60	$C_{22}H_{44}O_3S$	64
15.880	Octanoic acid-tert bytyl ester	200.32	C12H24O2	37
17.512	meso-2,3-Diisobutyl-2,3-dimethylsuccinic acid dinitrile	---	---	72

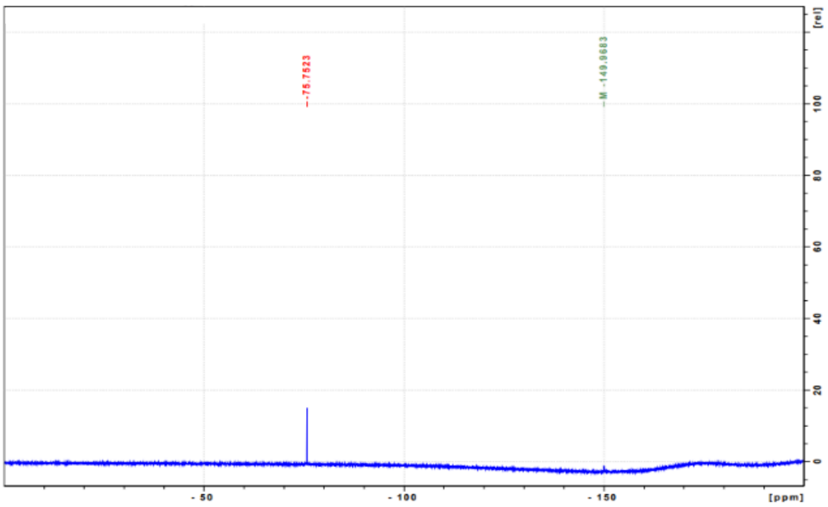


	(ultraviolet absorvent UV-329)			
22.438	1,1,2,2-tetramethyl-1,2-digermacyclopentane	247.50	$C_7H_{18}Ge_2$	56
22.954	Dibutyl phthalate	278.34	$C_{16}H_{22}O_4$	93
24.056	11,13-Dimethyl-12-tetradecen-1-ol acetate 9-Decen-1-ol, trifluoroacetate	282.46 252.27	$C_{18}H_{34}O_2$ $C_{12}H_{19}F_3O_2$	74 68
24.662	3-(2,5-Dimethyl-1H-pyrrole-3-yl)-1,3-dihydro-indol-2-one	---	---	90
25.968	Bisphenol A	228.29	$C_{15}H_{16}O_2$	98

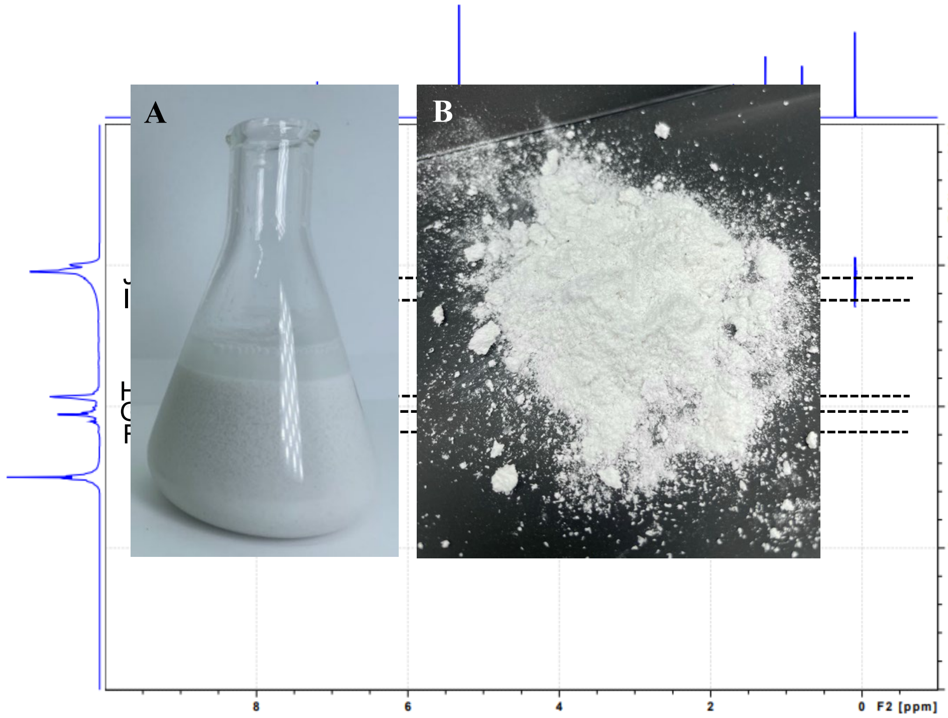
Supplementary Fig. 8. ^{1}H DOSY NMR of ophthalmic wastewater obtained in the final stage of 187 eyeglass lens grinding.

Supplementary Table 10. The measurement of ophthalmic wastewater was done at 25ºC in deuterated chloroform. [a] ^{1}H DOSY NMR experiment. [b] Hydrodynamic radius calculated via the Stokes-Einstein equation $D = k_B T / 6\pi\eta r_H$ (k_B, Boltzmann constant; T, absolute temperature; η, viscosity of $CDCl_3$ at 298 K); * Molecular weights above 1000 g/mol suggest aggregation in solution.

Compound	Diffusion coefficient (10-10 m2/s) a	Hydrodynamic radius (nm)b	Molecular weight (g/mol)
A	8.8	1.58 × 10-9	173
B	9.1	7.94 × 10-10	413
C	9.17	6.76 × 10-10	944
D	9.7	1.99 × 10-10	18296*
E	10.01	9.77 × 10-11	129031*



Supplementa eyeglass lens grinding.



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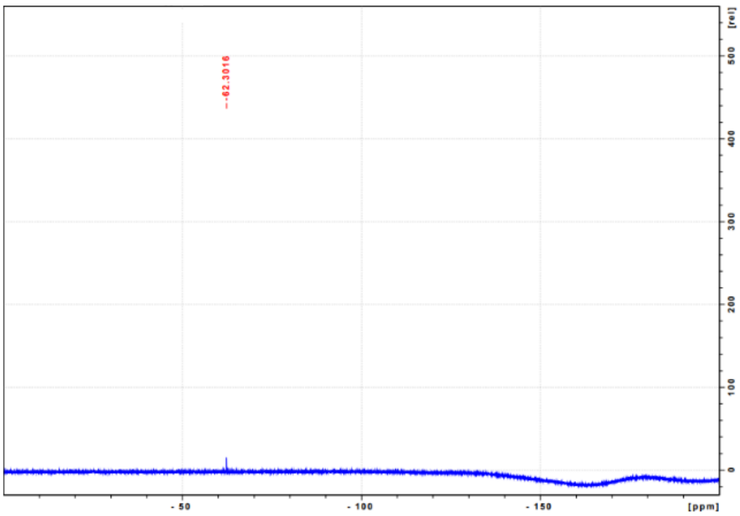
Sup euterated chloroform. [a] ^{1}H DOSY NMR experiment. [b] Hydrodynamic radius calculated via the Stokes-Einstein equation $D = k_B T / 6\pi\eta r_H$ (k_B, Boltzmann constant; T, absolute temperature; η, viscosity of $CDCl_3$ at 298 K); * Molecular weights above 1000 g/mol suggest aggregation in solution.

Compound	Diffusion coefficient (10^{-10} m^2/s) [a]	Hydrodynamic radius (nm) [b]	Molecular weight (g/mol)
F	8.8	1.58×10^{-9}	246
G	9.06	8.71×10^{-10}	550
H	9.13	7.41×10^{-10}	773
I	9.8	1.58×10^{-10}	33991*
J	9.9	1.26×10^{-10}	64703*



Supplementary ge of 187 eyeglass lens grinding.

Supplementary Fig. 12. Optic industry wastewater supernatant obtained in the final stage of eyeglass lens grinding (**A**) and solids from ophthalmic spectacle lens wastewater (**B**).

Supplementary Table 12. Technical specifications of ISO 20' standard marine container and volumetric analogy.

ISO 20' standard marine container	Parameter	Value	Source/Note
Container Dimensions	Internal Length	5,900 mm	ISO 20' Standard
	Internal Width	2,352 mm	ISO 20' Standard
	Internal Height	2,395 mm	ISO 20' Standard
Container Capacity	Internal Volume	33.2 m^3	Calculated
	Max Payload	28,130 kg	ISO 20' Standard
Waste Characteristics	Material Density	*1.3 t/m³*	https://doi.org/10.3390/ma17010075
Annual Scale	Total Waste	*5,770,000 kg*	Calculated
	Container Count	206 Units	(Total Waste / Max Payload per Unit)
	Extended Scale	721 Units	Based on 3.5x multiplier (accordingly latest reports)

* The number of containers was determined by dividing the total estimated annual waste by the structural weight limits of maritime transport (Max Payload) of a standard ISO 20' container (28,130 kg). This ensures the analogy accounts for the structural weight limits of maritime transport.