Development of a technology for reducing polycyclic aromatic hydrocarbons in smoked food and smoked ingredients

Article

Supplemental Material

Development of a Zeolite Filter for Removing Polycyclic Aromatic Hydrocarbons from Smoked Food and Smoked Ingredients

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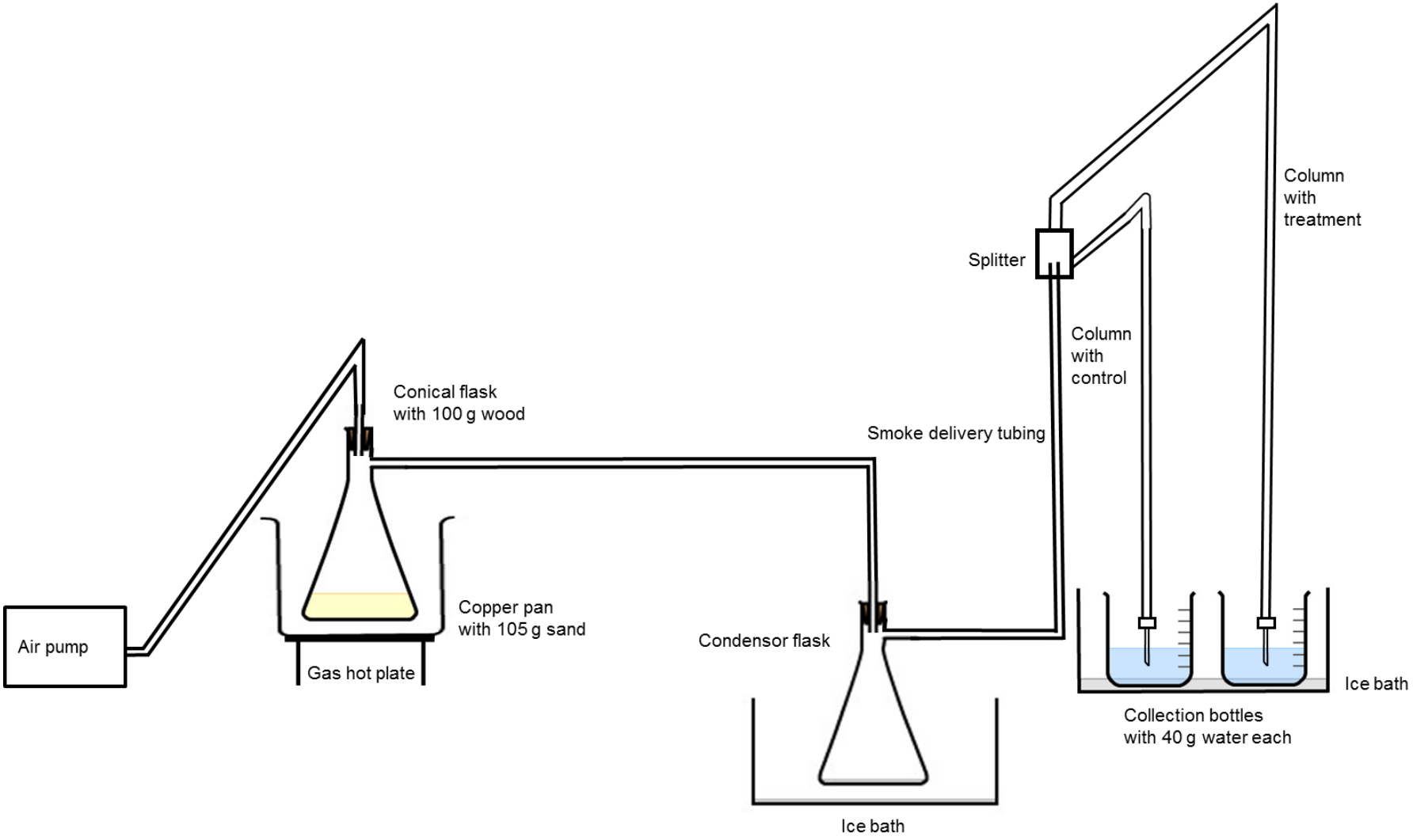

Figure S1 Dual stream laboratory scale smoker

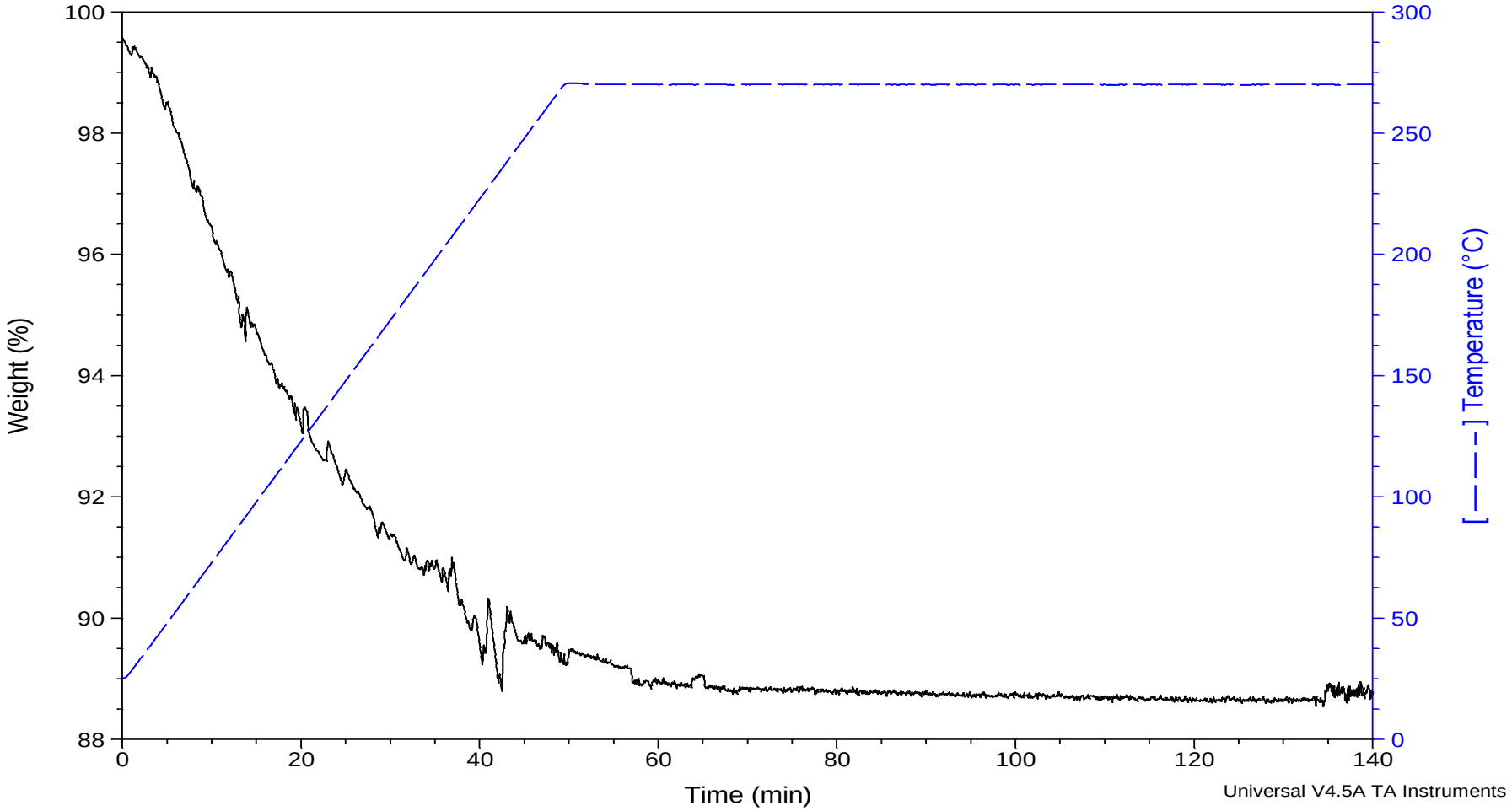

Figure S2 Weight loss in clinoptilolite sample upon heating

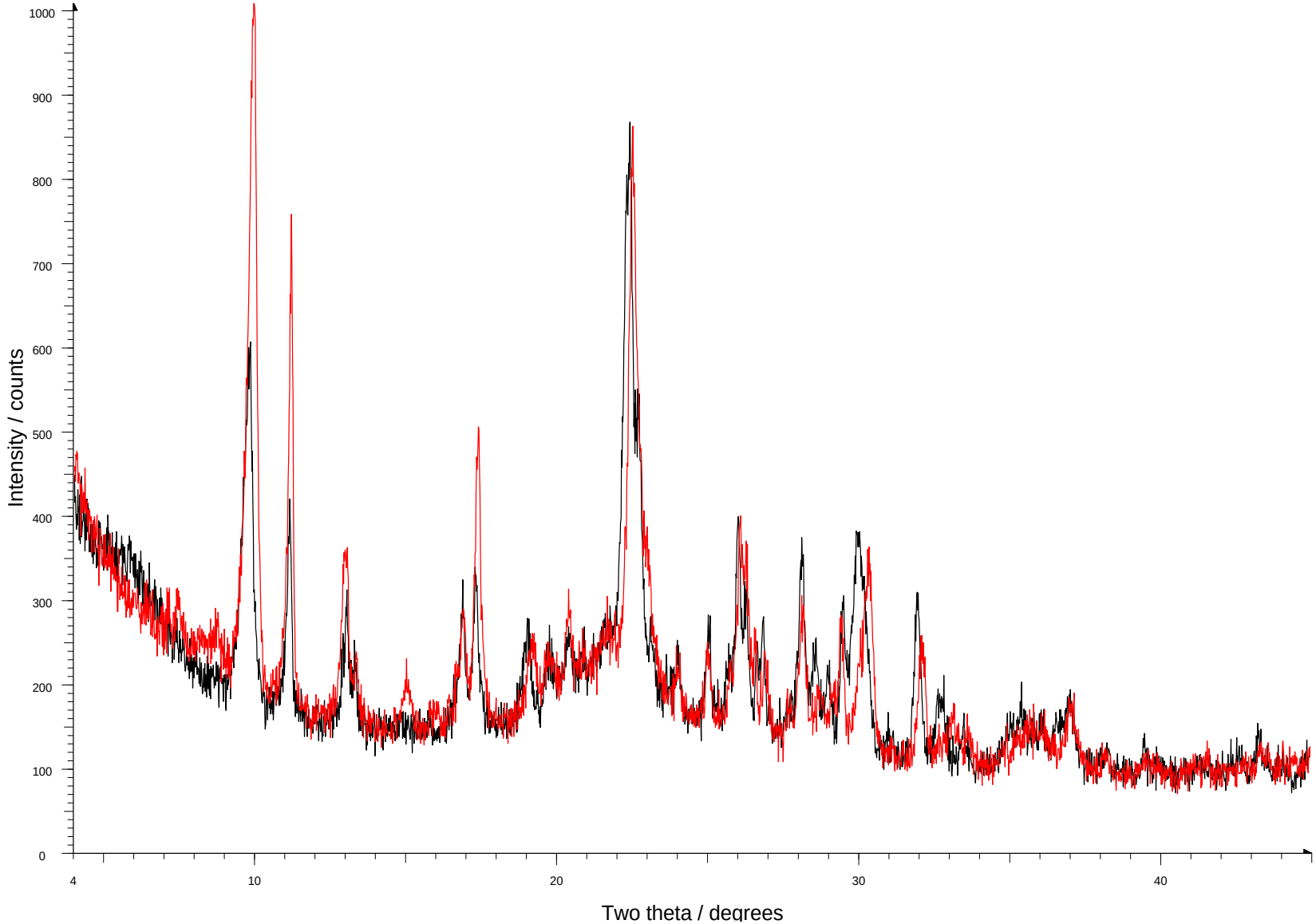

Figure S3 Diffraction pattern for clinoptilolite sample at 20 °C (black) and 220 °C (red)

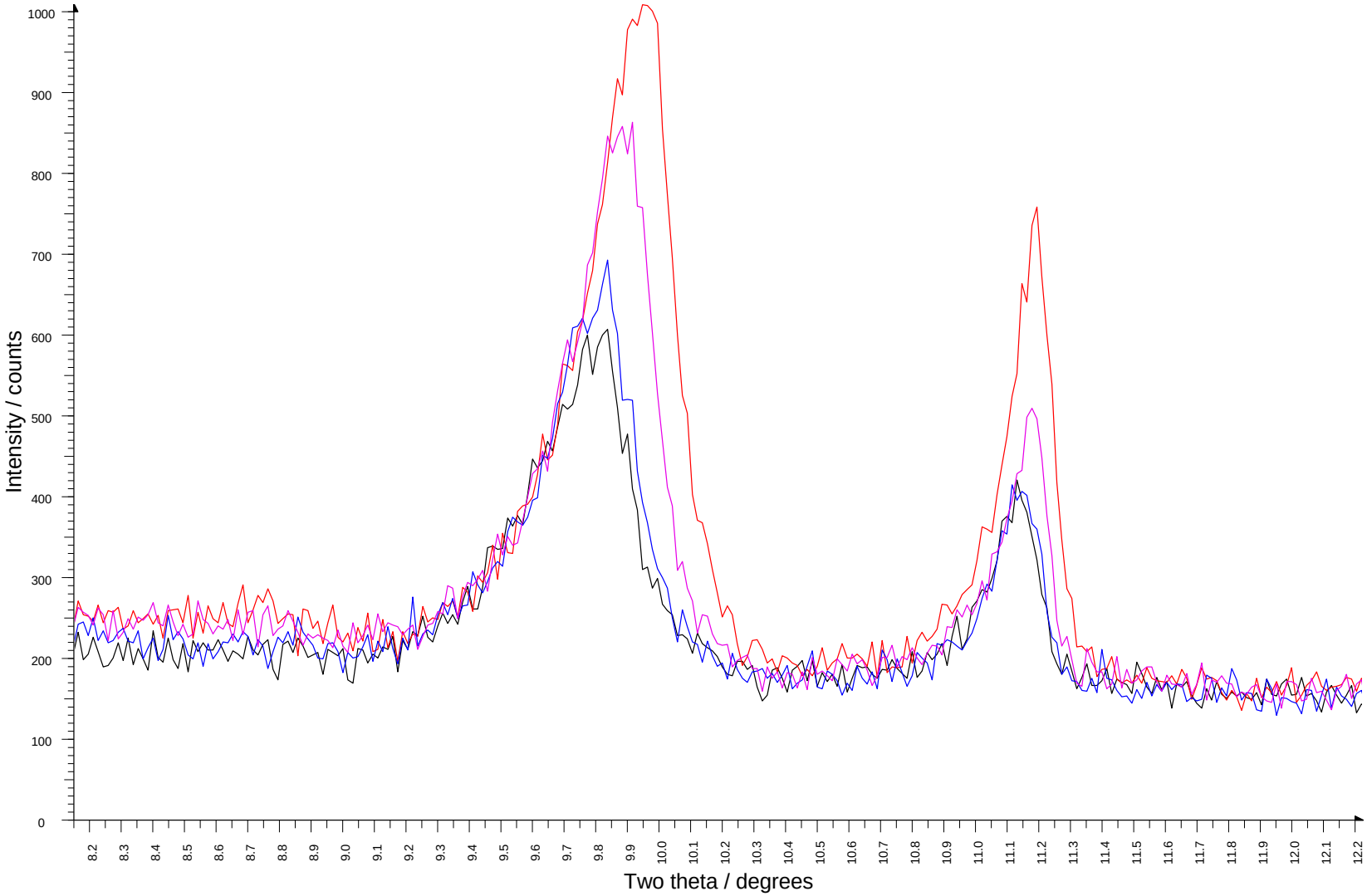

Figure S4 Low angle range of diffraction pattern for clinoptilolite at 20 °C (black), 100 °C (blue), 140 °C (purple) and 220 °C (red)

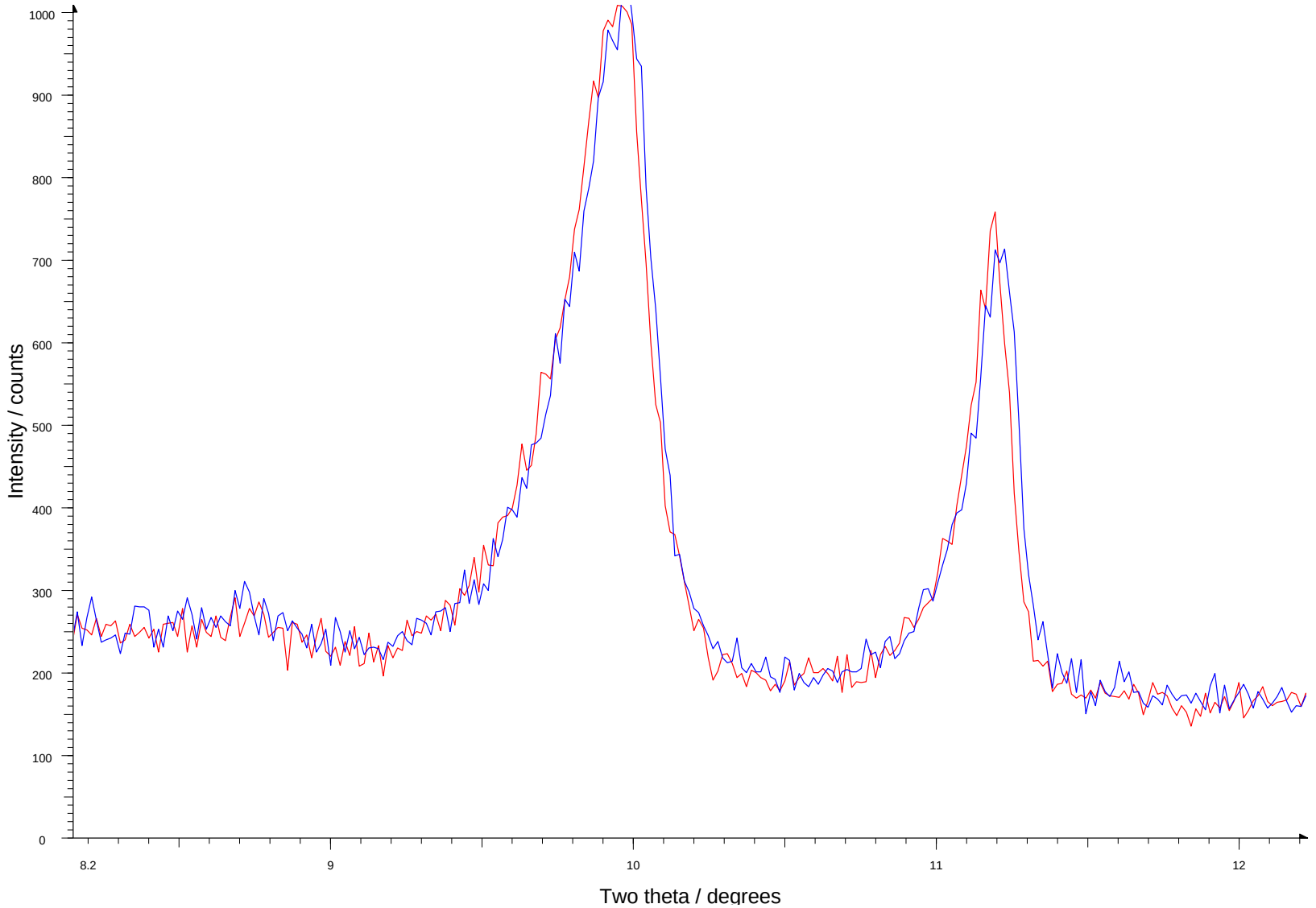

Figure S5 Low angle range of diffraction pattern for clinoptilolite at 220 °C (red) and after cooling back to 20 °C (blue)

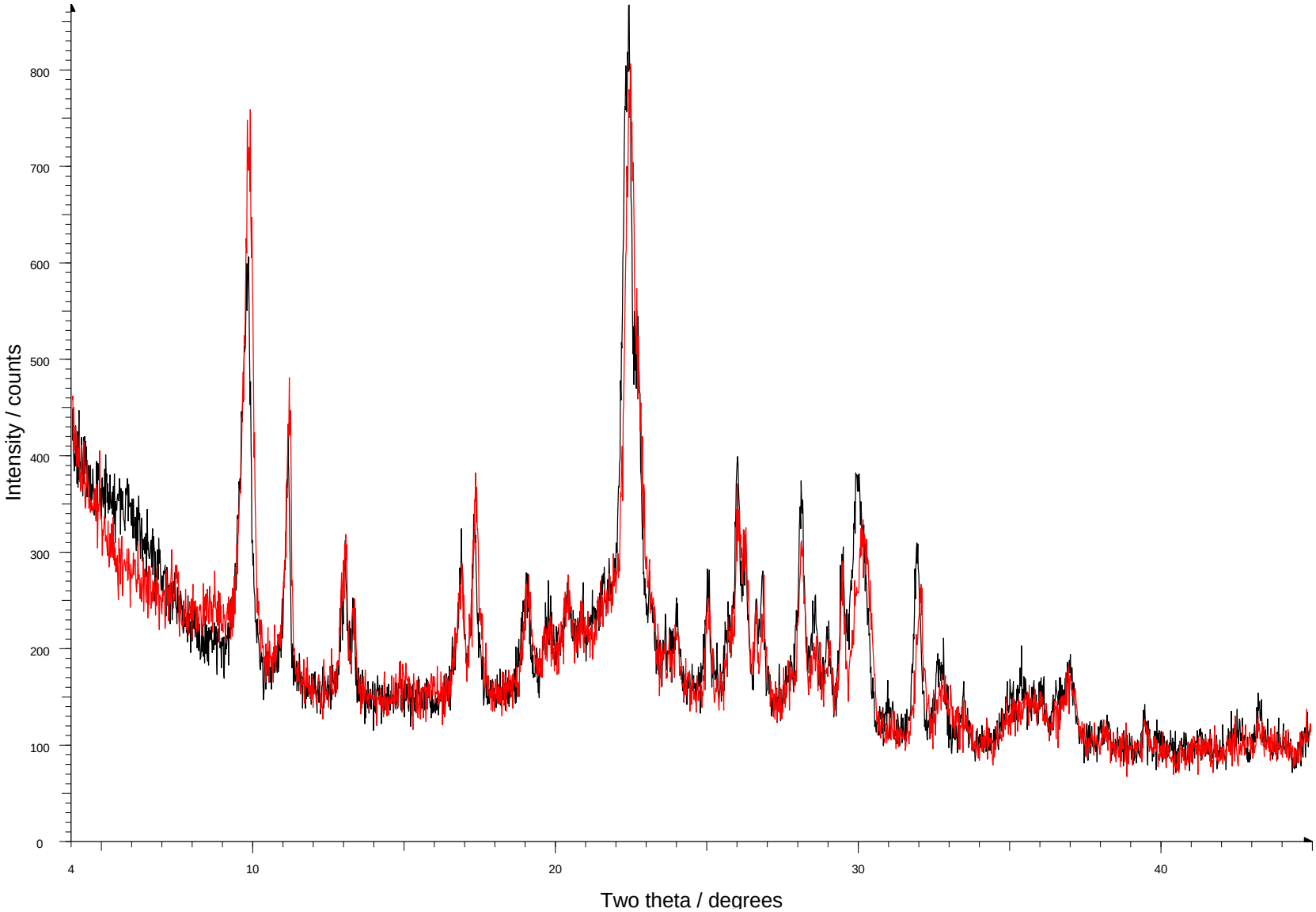

Figure S6 Diffraction pattern for clinoptilolite sample at 20 °C (black) and the previously heated sample after standing for 4 days exposed to the atmosphere (red)

Table S1 Volatiles: Mean Peak Areas (n=3), Standard Deviation and % Coefficient of Variation for Pilot Scale Smoking of Rapeseed Oil (Experiment 10)

LRI DB5	compound	Qion[a]	none[b] mean	none std dev	none % cv	size 5 mean	size 5 std dev	size 5 % cv	size 3 mean	size 3 std dev	size 3 cv	size 2 mean	size 2 std dev	size 2 cv
835	2-furancarboxaldehyde	96	78247493	761383	1%	80534776	634338	1%	89122385	1746801	2%	92530126	1200822	1%
854	2-furanmethanol	81	389246	3564	1%	464687	9534	2%	357144	21097	6%	289957	18360	6%
913	1-(2-furanyl)ethanone	95	9961879	54499	1%	9048344	124775	1%	11103657	266468	2%	9746790	443504	5%
967	5-methyl-2-furancarboxaldehyde	110	630170	5435	1%	569276	12042	2%	606233	32037	5%	630433	51548	8%
977	phenol	94	4556143	437714	10%	3224400	194891	6%	4302680	837660	19%	1433321	202519	14%
1006	benzofuran	118	2353742	23904	1%	1412380	31753	2%	2632383	155153	6%	1463661	145671	10%
1031	3-methylcyclopentane-1,2-dione	112	2399992	189350	8%	1955103	80021	4%	1336488	297007	22%	334229	60560	18%
1041	1-(5-methyl-2-furanyl)ethanone	109	1594784	84804	5%	1096889	13111	1%	1566030	231282	15%	808922	105626	13%
1050	benzeneacetaldehyde	91	326879	15892	5%	260517	4822	2%	236179	35993	15%	161413	28896	18%
1053	2-methylphenol	107	975366	109571	11%	662312	49205	7%	861900	233233	27%	302392	63529	21%
1073	3/4-methylphenol	107	856033	101550	12%	554119	46228	8%	690810	212564	31%	153335	36406	24%
1094	2-methoxyphenol	109	13638086	1126801	8%	9999456	516576	5%	11716997	2010289	17%	6643439	961056	14%
1134	1-(5-methyl-2-furanyl)propan-1-one	109	289116	23805	8%	182369	8176	4%	251417	64269	26%	121627	24932	20%
1199	4-methyl-2-methoxyphenol	138	4657977	572054	12%	3170625	251264	8%	3317359	1035953	31%	1278912	342591	27%
1287	4-ethyl-2-methoxyphenol	137	1505062	185467	12%	944114	59900	6%	908163	316252	35%	304762	107190	35%
1298	5-butyl-4-methyldihydrofuran-2(3H)-one[c]	99	41980	3826	9%	27144	2578	9%	23708	3937	17%	10497	1042	10%
1322	4-ethenyl-2-methoxyphenol	150	133474	18078	14%	82903	2368	3%	36599	17415	48%	12663	8159	64%
1332	5-butyl-4-methyldihydrofuran-2(3H)-one[c]	99	61439	5265	9%	39498	1656	4%	27991	6402	23%	8157	2713	33%
1358	1,3-dimethoxy-2-hydroxybenzene	154	587615	46832	8%	431996	11783	3%	190925	68837	36%	35765	24292	68%
1367	2-methoxy-4-prop-2-enylphenol	164	23231	3241	14%	15631	413	3%	9356	3832	41%	3130	203	6%
1406	4-Hydroxy-3-methoxybenzaldehyde	151	19755	1373	7%	14110	6159	44%	5935	2920	49%	836	78	9%
1409	(*E*)-2-methoxy-4-[prop-1-enyl]phenol	164	7821	3338	43%	4504	1259	28%	3042	1615	53%	nd		
1428	4-hydroxy-3-methoxybenzoic acid	168	155744	20011	13%	118967	21026	18%	23385	13885	59%	3307	2800	85%
1431	(*Z*)-2-methoxy-4-[prop-1-enyl]phenol	164	17934	3052	17%	8968	3001	33%	4400	2647	60%	nd		

[a]Ion used for peak area [b]zeolite grain size [c]unspecified mix of isomers

Table S2 Volatiles: Peak Areas for Manufacturing Scale Smoking of Rapeseed Oil with Different % of Zeolite in the Filter (Experiment 12)

LRI DB5	compound	[a]QIon	[b]none	none	30%	30%	40%	40%	50%	50%
835	2-furancarboxaldehyde	96	14021578	13315880	16458874	15418541	16431977	15434322	16812792	15636980
854	2-furanmethanol	81	1045897	1077456	418771	406065	281572	261942	225016	206241
913	1-(2-furanyl)ethanone	95	1671902	1714167	1531333	1504804	1290569	1258094	1240625	1195385
967	5-methyl-2-furancarboxaldehyde	110	6314159	6272790	7442422	7174066	6016559	5774170	5881587	5615542
977	phenol	94	2057979	2016583	1542074	1537018	1008964	991750	948597	932441
1006	benzofuran	118	2237175	2312939	1109072	1115038	1675492	1662974	2008208	1964984
1031	3-methylcyclopentane-1,2-dione	112	1336073	1361536	1117210	1123712	548556	558024	375790	374891
1041	1-(5-methyl-2-furanyl)ethanone	109	439081	457365	349259	356028	232237	230506	201618	198037
1050	benzeneacetaldehyde	91	91441	94387	100390	103092	81813	82706	83722	82491
1053	2-methylphenol	107	607514	583190	366144	362121	232306	224139	206241	192801
1073	3/4-methylphenol	107	1170485	1094785	686830	654879	432314	414874	357185	355499
1094	2-methoxyphenol	109	5928540	5757944	5506913	5429685	3814196	3676775	3508115	3413467
1134	1-(5-methyl-2-furanyl)propan-1-one	109	238693	230956	110385	113405	89470	89403	78078	77615
1199	4-methyl-2-methoxyphenol	138	4640182	4270863	4818400	4490992	3059755	2915786	2587505	2564097
1287	4-ethyl-2-methoxyphenol	137	3263892	2957131	2595882	2324274	1461332	1424305	1077508	1126521
1298	5-butyl-4-methyldihydrofuran-2(3H)-one[c]	99	53346	44120	34974	30641	21493	20847	18172	19075
1322	4-ethenyl-2-methoxyphenol	150	754554	734885	617503	552315	359683	360256	289449	309015
1332	5-butyl-4-methyldihydrofuran-2(3H)-one[c]	99	92246	83728	70511	61418	42266	41136	33381	34812
1358	1,3-dimethoxy-2-hydroxybenzene	154	1079130	1026500	637556	568004	307890	297280	200345	214574
1367	2-methoxy-4-prop-2-enylphenol	164	161836	157903	142313	127306	85885	88235	68388	75791
1406	4-Hydroxy-3-methoxybenzaldehyde	151	64276	70689	88342	78400	49553	47703	33994	35917
1409	(*E*)-2-methoxy-4-[prop-1-enyl]phenol	164	76605	80185	64768	60610	37729	39488	28608	31180
1428	4-hydroxy-3-methoxybenzoic acid	168	306784	310010	202869	179728	91499	90156	55160	55263
1431	(*Z*)-2-methoxy-4-[prop-1-enyl]phenol	164	164795	189781	155672	150588	99159	101754	75339	79820

[a]Ion used for peak area [b]zeolite (%) incorporated into the filter [c]unspecified mix of isomers

Table S3 Volatiles: Mean Peak Areas (n=3), Standard Deviation and % Coefficient of Variation for Tomato Ketchup with 2% Smoked Oil Added

LRI DB5	compound	Qion[a]	none[b] mean	none std dev	none % cv	size 5 mean	size 5 std dev	size 5 % cv	size 3 mean	size 3 std dev	size 3 cv	size 2 mean	size 2 std dev	size 2 cv
835	2-furancarboxaldehyde	96	26243367	421942	2%	26616939	842003	3%	30062215	552535	2%	30769505	758802	2%
854	2-furanmethanol	81	11645	3620	31%	12229	4846	40%	10263	3854	38%	9044	3439	38%
913	1-(2-furanyl)ethanone	95	2468821	38849	2%	2198335	58101	3%	2888295	79993	3%	2375052	137439	6%
967	5-methyl-2-furancarboxaldehyde	110	11979093	330588	3%	9969944	319719	3%	13219035	421752	3%	9638645	971311	10%
977	phenol	94	1376699	31995	2%	967419	41915	4%	1292937	46613	4%	437419	51207	12%
1006	benzofuran	118	3039399	147426	5%	1691983	211108	12%	3532506	321309	9%	1903139	321586	17%
1031	3-methylcyclopentane-1,2-dione	112	54532	9672	18%	44219	8011	18%	27872	309	1%	6361	1226	19%
1041	1-(5-methyl-2-furanyl)ethanone	109	521420	18089	3%	362917	17480	5%	542824	34479	6%	271400	42133	16%
1050	benzeneacetaldehyde	91	221913	7935	4%	180181	9821	5%	194667	14905	8%	163834	26774	16%
1053	2-methylphenol	107	774892	23503	3%	527382	23430	4%	689822	38456	6%	242544	37528	15%
1073	3/4-methylphenol	107	545181	19653	4%	352985	18364	5%	446767	23720	5%	104147	17449	17%
1094	2-methoxyphenol	109	7766130	227133	3%	5537219	239364	4%	6707230	279131	4%	3630831	574448	16%
1134	1-(5-methyl-2-furanyl)propan-1-one	109	249255	11139	4%	158859	9187	6%	221823	18225	8%	103412	21487	21%
1199	4-methyl-2-methoxyphenol	138	4347489	176542	4%	3003770	132490	4%	3153931	190602	6%	1245640	242308	19%
1287	4-ethyl-2-methoxyphenol	137	2093710	100145	5%	1346973	65664	5%	1337249	88835	7%	443501	91476	21%
1322	4-ethenyl-2-methoxyphenol	150	144232	11718	8%	94122	4645	5%	41650	2770	7%	12382	2984	24%
1332	5-butyl-4-methyldihydrofuran-2(3H)-one	99	68182	2421	4%	43075	2425	6%	31437	1390	4%	8567	1252	15%
1358	1,3-dimethoxy-2-hydroxybenzene	154	89836	14990	17%	65829	12749	19%	34113	2643	8%	4911	996	20%
1406	4-Hydroxy-3-methoxybenzaldehyde	151	1906	444	23%	1377	674	49%	573	154	27%	nd		
1428	4-hydroxy-3-methoxybenzoic acid	168	50481	5656	11%	40516	5767	14%	11340	1405	12%	142	246	173%

[a]Ion used for peak area [b]zeolite grain size used in the filter during the smoking of the oil