

Supplementary material:

1. Detailed experimental results:

The evolution of thermal parameters with the heating rate obtained from differential thermogravimetric (DTG) curves has been summarised in Tables S1 and S2.

Table S1. Detailed experimental results for raw materials combustion.

	β (°C.min ⁻¹)	First stage				Second stage				Δt (min)
		T_i (°C)	T_f (°C)	T_{max} (°C)	r_{max} (%/s)	T_i (°C)	T_f (°C)	T_{max} (°C)	r_{max} (%/s)	
Flax shives	10	228	335	318	0.198	404	436	426	0.12	20.80
	20	227	356	326	0.329	395	436	418	0.215	10.45
	30	269	367	326	0.455	401	444	416	0.243	5.83
	40	264	379	330	0.577	394	446	418	0.252	4.55
Beech wood	10	245	339	325	0.25	431	444	437	0.164	19.90
	20	257	355	338	0.422	429	445	437	0.238	9.40
	30	265	358	342	0.623	406	441	422	0.293	5.87
	40	268	367	346	0.702	412	451	431	0.371	4.58
Hemicellulose	10	207	314	291	0.132	448	561	515	0.046	35.40
	20	216	329	305	0.317	464	585	531	0.081	18.45
	30	225	337	311	0.492	475	600	549	0.108	12.50
	40	231	345	316	0.682	483	614	557	0.124	9.58
Cellulose	10	297	335	323	0.491					3.80
	20	312	352	337	0.734					2.00
	30	317	364	345	0.87					1.57
	40	318	372	350	0.915					1.35
Lignin	10	227	346	314	0.043	806	837	823	0.389	61.00
	20	247	368	324	0.079	801	851	831	0.413	30.20
	30	248	374	325	0.113	798	859	833	0.556	20.37
	40	253	384	330	0.138	797	868	835	0.585	15.38

Table S2. Detailed experimental results for char samples combustion.

	β (°C.min ⁻¹)	T_i (°C)	T_f (°C)	Δt (min)	T_{max} (°C)	r_{max} (%/s)
Flax shives char	10	441	479	3.800	458	0.234
	20	439	538	4.950	495	0.263
	30	418	603	6.167	537	0.264
	40	414	666	6.300	566	0.248
Beech wood char	10	441	501	6.000	468	0.282
	20	449	544	4.750	494	0.334
	30	451	605	5.133	522	0.292
	40	454	675	5.525	553	0.296
Hemicellulose char	10	532	620	8.800	587	0.208
	20	548	655	5.350	636	0.303
	30	532	688	5.200	643	0.347
	40	548	702	3.850	674	0.399
Cellulose char	10	513	627	11.400	587	0.235
	20	541	680	6.950	608	0.325
	30	535	711	5.867	619	0.389
	40	541	763	5.550	634	0.433
Lignin char	10	748	801	5.300	784	0.279

20	754	841	4.350	801	0.331
30	752	877	4.167	815	0.362
40	767	956	4.725	828	0.296

A detailed table of kinetic parameters for the raw materials and the char samples are shown in Table S3.

Table S3. Detailed kinetic parameters for all raw materials.

	Raw materials										
	β ($^{\circ}\text{C}\cdot\text{min}^{-1}$)	First stage				Second stage			Char samples		
		E_a ($\text{kJ}\cdot\text{mol}^{-1}$)	$\log A$	R^2	E_a ($\text{kJ}\cdot\text{mol}^{-1}$)	$\log A$	R^2	E_a ($\text{kJ}\cdot\text{mol}^{-1}$)	$\log A$	R^2	
Flax shives	10	82.39	9.52	0.995	67.95	4.95	0.948	157.23	17.97	0.998	
	20	80.05	8.95	0.994	68.86	5.42	0.931	144.36	17.36	0.969	
	30	83.67	8.55	0.993	66.61	5.46	0.981	122.93	17.12	0.960	
	40	84.05	9.23	0.994	64.16	5.22	0.982	115.09	16.89	0.964	
Beech wood	10	97.15	11.33	0.994	81.41	10.54	0.982	178.00	21.07	0.997	
	20	98.71	11.74	0.994	78.44	9.90	0.976	157.56	15.95	0.996	
	30	102.37	11.83	0.997	79.01	9.50	0.967	140.46	12.32	0.996	
	40	98.84	11.21	0.998	79.18	10.73	0.962	130.70	10.11	0.989	
Hemicellulose	10	156.92	23.04	0.931	63.08	1.59	0.941	195.58	30.39	0.995	
	20	165.02	23.19	0.946	64.49	1.74	0.907	192.41	29.69	0.995	
	30	185.24	26.63	0.947	68.34	1.75	0.963	165.25	31.34	0.961	
	40	182.14	25.33	0.957	68.40	1.60	0.949	168.02	29.36	0.967	
Cellulose	10	206.92	34.93	0.997				224.20	23.15	0.999	
	20	220.44	34.41	0.998				221.81	21.32	0.998	
	30	216.44	33.25	0.998				216.19	19.57	0.998	
	40	205.04	31.14	1.000				211.25	18.14	0.997	
Lignin	10	45.15	1.31	0.998	364.00	27.00	0.986	296.41	23.44	0.998	
	20	46.10	1.30	0.896	354.11	29.15	0.984	243.10	22.95	0.998	
	30	46.72	1.37	0.919	336.44	26.84	0.955	263.91	19.14	0.964	
	40	45.92	1.48	0.922	339.16	17.38	0.955	252.24	16.61	0.967	

2. Table of activation energy of biomass and char combustion found in literature:

Table S4. Activation energy of biomass combustion found in literature.

Biomass	E_a ($\text{kJ}\cdot\text{mol}^{-1}$)	Authors
Pine	First stage 102.3	[1]
	Second stage 236.1	
Sludge pellet	157.47-159.13	[2]
Camphor pellet	129.61-126.97	[2]
Pine	123–136	[3]
Date palm residue	9.04-30.95	[4]
Sewage sludge	86-99	[5]
Strawdust	91.12	
Wheat straw 1	109.3	[6]
Wheat straw 2	88.2	
B sewage sludge	70.1	
F sewage sludge	62.3	[7]
S sewage sludge	40.9	
Sewage sludge	143	[8]
Date palm leaflets	58.9	
Date palm rachis	49.6	[9]
Date palm trunk	67.6	

Date stones	57.7	
Fruitstalk prunings	110.7	
Cotton stalk	113	
Shea meal	108	[10]10
Sugarcane bagasse 1	75	
Sugarcane bagasse 2	116	
Sawdust	107.8	[11]
Corn stover	57.32	[12]
Corn stalks skins	126	[13]
Cornstalks cores	101	
Chlorella pyrenoidosa	65.15	[14]
Spirulina platensis	84.29	
Robinia pseudoacacia	130	[15]
Waste wood	110	
Saw dust	32.8	[16]
Rice husk	25.2	
Wood chips	24	
Olive husk	35	[16]
Pine seed shells	26	
Cellulosic paper	160	[17]
Cellulose	212	[18]
Lignin	69.5	

Table S5. Activation energy of char combustion found in literature.

Origin of char	E_a (kJ/mol)	Authors
Wood**	145.3	
Cotton residue	149.9	[19]
Forest residue	130.0	
Strawdust	52.8	
Wheat straw 1	171.1	[6]
Wheat straw 2	154.2	
Pine wood	125	[20]
Cellulosic paper	160	[17]

** Author did not specify the type of wood.

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