Supplementary Materials

Prediction of fuel properties of torrefied biomass based on back propagation neural network optimized by genetic algorithm

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Table.S1. Dataset.

Biomass	Torrefaction condition	Ref.
olive residue, almond shell	N_2, 275 ℃, 60 min	[1]
olive tree	He, 220~280 ℃, 60~360 min	[2]
rice husk	Ar, 220~270 ℃, 30~60 min	[3]
coffee grounds	N_2, 200~300 ℃, 30 min	[4]
banana leaf waste	N_2, 220~280 ℃, 1 min	[5]
rice straw, rice husk	N_2, 200~300 ℃, 30 min	[6]
pearl millet, walnut shell	N_2, 230~300 ℃, 30~90 min	[7]
ash tree, hazelnut shell, refuse-derived fuel	N_2, 230~290 ℃, 30 min	[8]
garden waste	Ar, 200~300 ℃, 30~60 min	[9]
mixture of municipal organic wastes and biomass	N_2, 200~275 ℃, 30 min	[10]
empty fruit bunches	N_2, 225~300 ℃, 40 min	[11]
oil palm empty fruit bunch	N_2, 250~300 ℃, 30 min	[12]
caragana	N_2, 225~275 ℃, 10~20 min	[13]
pellet consists of 80% larch and 20% oak	anoxic, 200~270 ℃, 20~40 min	[14]
rice straw, bamboo dust	N_2, 250 ℃, 15 min	[15]
pine sawdust	N_2, 260~300, 11 min	[16]
ananas comosus peel, annona squamosa peel	N_2, 210~300 ℃, 30~60 min	[17]
eucalyptus grandis	N_2, 230~290 ℃, 60 min	[18]
leucaena leucocephala	N_2, 260~300 ℃, 0~30 min	[19]

Biomass	Torrefaction condition	Ref.
moso bamboo	N_2, 200~300 ℃, 60~120 min	[20]
rice husk, rice straw	N_2, 200~300 ℃	[21]
pongamia seed pods	N_2, 200~300 ℃, 60 min	[22]
rubberwood	N_2, 200~300 ℃, 20~60 min	[23]
cellulose	N_2, 200~290 ℃, 30 min	[24]
fruit waste	N_2, 210~300 ℃, 30~60 min	[25]
empty fruit bunches	N_2, 225~300 ℃, 20~60 min	[26]
mustard crop residue	N_2, 200~300 ℃, 30~60 min	[27]
pine, kenaf	N_2, 250 ℃, 30 min	[28]
prosopis juliflora	N_2, 230~270 ℃, 30 min	[29]
sugarcane bagasse	N_2, 230~280 ℃, 30~45 min	[30]
orange peel	N_2, 220~280 ℃, 30 min	[31]
rice husk, rice straw	N_2, 200~300 ℃, 60 min	[32]
poplar wood	N_2, 200~300 ℃, 60 min	[33]
olive kernel	N_2, 300 ℃, 60 min	[34]
rice husk	oxygen-deficient, 240~280 ℃, 0~90 min	[35]
miscanthus, hops waste	oxygen-deficient, 250 ℃, 60 min	[36]
waste vine shoots	N_2, 220~280 ℃, 10~60 min	[37]
almond shells, olive stones	N_2, 250~300 ℃, 45 min	[38]
sugarcane leaves	N_2, 225~300 ℃, 30 min	[39]
corncob	N_2, 210~300 ℃, 30 min	[40]
bamboo forest residues	N_2, 200~300 ℃, 60 min	[41]
leftover rice, leftover cabbage, leftover pork, watermelon peel	Ar, 200~300 ℃, 30 min	[42]
wooden block	N_2, 220~280 ℃, 40 min	[43]
sugarcane bagasse	N_2, 200~275 ℃, 60 min	[44]
sorghum straw	N_2, 230~300 ℃, 30~108 min	[45]
pigeon pea stalk, eucalyptus	N_2, 200~300 ℃, 30 min	[46]
sorghum straw	N_2, 230~300 ℃, 10 min	[47]
rice straw	N_2, 200~250 ℃, 45 min	[48]
pine wood, rice husk	N_2, 210~300 ℃, 30 min	[49]
rice husk	N_2, 220~300 ℃, 30 min	[50]
mixture of waste wood, oak waste wood and sewage sludge	oxygen-deficient, 220~300 ℃, 120 min	[51]
corncob, rice husk	N_2, 200~300 ℃, 30~60 min	[52]
ponkan peel waste	N_2, 200~300 ℃, 15~60 min	[53]
black alder	N_2, 250~300 ℃, 30~60 min	[54]
Norway spruce	N_2, 225~275 ℃, 30~60 min	[55]
sugarcane bagasse	N_2, 200~300 ℃, 15~60 min	[56]
pigeon pea stalk	N_2, 225~275 ℃, 15~45 min	[57]
rice husk	N_2, 210~300 ℃, 30 min	[58]
wood biomass	Ar, 230~290 ℃, 60 min	[59]
pine wood	N_2, 250~290 ℃, 30~60 min	[60]

Biomass	Torrefaction condition	Ref.
vine pruning, olive tree pruning, corn stalk, poultry litters	N_2, 300 ℃, 30 min	[61]
rice straw, cotton stalk	N_2, 210~290 ℃, 20~60 min	[62]
cotton stalk, corn stalk	N_2, 200~290 ℃, 30 min	[63]
oil palm fiber, Eucalyptus	N_2, 250~300 ℃, 60 min	[64]
willow, reed canary grass, wheat straw	N_2, 230~290 ℃, 30 min	[65]
rice straw	N_2, 200~300 ℃, 60 min	[66]

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Table S2. Parameter values and basic settings of the BPNN-GA model.

	Parameters	Values
BPNN	Structure	One hidden layer back propagation
	Hidden neurons	4-14
	Learning ratio	0.01
	Momentum factor	0.01
	Number of data samples	497
	Ratio of training data	0.8
	Ratio of testing data	0.2
GA	Population size	80
	Chromosome length	13X+6
	Maximum generation	300
	Crossover fraction	0.8
	Migration fraction	0.01

Table S3. Pearson correlation coefficient between any two features

	MO	VM	ASH	FC	Temp	Time	FR	O/C	H/C	HHV	MY	EY
MO	1	-0.03771	-0.09897	-0.37075	-0.03035	-0.04833	0.037311	-0.20386	-0.19213	-0.03871	0.054822	-0.03457
VM	-0.03771	1	-0.34212	-0.61335	0.03735	-0.01406	-0.32559	0.044149	0.148177	-0.01071	-0.01344	0.019636
ASH	-0.09897	-0.34212	1	0.141089	-0.0777	-0.02876	0.192094	0.154517	-0.04417	-0.05151	0.164453	0.007463
FC	-0.37075	-0.61335	0.141089	1	0.054781	0.122013	0.237876	-0.05717	-0.12488	0.055843	-0.00095	-0.01165
Temp	-0.03035	0.03735	-0.0777	0.054781	1	0.002868	0.03945	-0.10698	0.023714	-0.06832	-0.04401	0.10832
Time	-0.04833	-0.01406	-0.02876	0.122013	0.002868	1	0.147655	-0.13014	-0.2308	0.199383	-0.12658	0.00709
FR	0.037311	-0.32559	0.192094	0.237876	0.03945	0.147655	1	-0.22565	-0.26535	-0.05553	-0.01796	-0.06987
O/C	-0.20386	0.044149	0.154517	-0.05717	-0.10698	-0.13014	-0.22565	1	0.235059	-0.01241	0.043467	-0.02176
H/C	-0.19213	0.148177	-0.04417	-0.12488	0.023714	-0.2308	-0.26535	0.235059	1	0.029617	-0.04189	0.096107
HHV	-0.03871	-0.01071	-0.05151	0.055843	-0.06832	0.199383	-0.05553	-0.01241	0.029617	1	-0.09244	-0.13891
MY	0.054822	-0.01344	0.164453	-0.00095	-0.04401	-0.12658	-0.01796	0.043467	-0.04189	-0.09244	1	0.010408
EY	-0.03457	0.019636	0.007463	-0.01165	0.10832	0.00709	-0.06987	-0.02176	0.096107	-0.13891	0.010408	1

Table S4. R2 and RMSE results of the training and testing set using BPNN model

	FR	H/C	O/C	HHV	MY	EY
R^2 (training)	0.8266	0.7555	0.7783	0.8646	0.8111	0.7201
RMSE (training)	0.161	0.0155	0.1075	1.6033	0.0794	0.0771
R^2 (testing)	0.4222	0.6667	0.7203	0.8145	0.7146	0.6487
RMSE (testing)	0.1782	0.0127	0.2444	1.8196	0.1467	0.0926

Figure S1. Comparison of BPNN predicted and experimental data of training set.

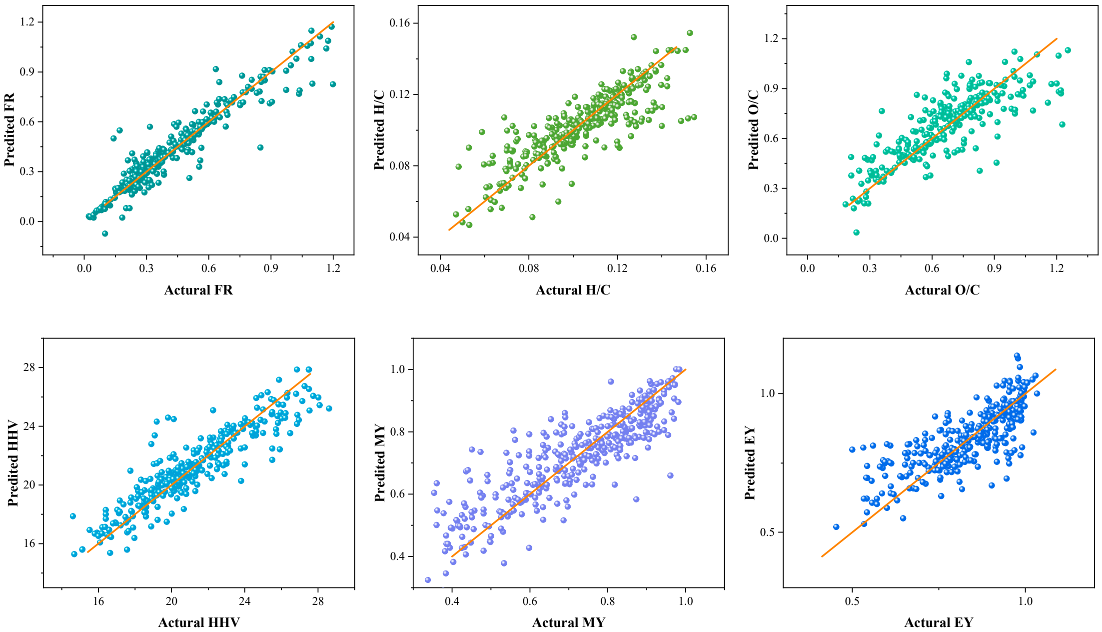

Figure S2. Comparison of BPNN predicted and experimental data of testing set.