Combustion of sewage sludge: Kinetics and speciation of the combustibles

Supporting Information

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6 pages, 4 figures

Step by step derivation of equation 4:

$$\frac{d\alpha}{dt} = f(\alpha)k(T)h(p) \qquad \text{(S1)}$$

Remove $h(p)$ as all experiments were conducted at constant partial pressures of oxygen.

$$\frac{d\alpha}{dt} = f(\alpha)k(T) \qquad \text{(S2)}$$

$$\int_0^{\alpha(t)} \frac{d\alpha}{f(\alpha)} = \int_0^{t(\alpha)} k(T)\, dt \qquad \text{(S3)}$$

We define the integrated reaction model (S4) and the Arrhenius equation (S5):

$$g(\alpha) \equiv \int_0^{\alpha} \frac{1}{f(\alpha)} d\alpha \qquad \text{(S4)}$$

$$k(T) = A \exp(-\frac{E}{RT}) \qquad \text{(S5)}$$

Insert the integration reaction model (S4) into equation S3:

$$g(\alpha) = \int_0^{t(\alpha)} k(T)\, dt \qquad \text{(S6)}$$

Insert equation S5 into equation S6:

$$g(\alpha) = A \int_0^{t} \exp\left(\frac{-E}{RT(t)}\right) dt \qquad \text{(S7)}$$

Equation S7 is equivalent to equation 4.

Figures:

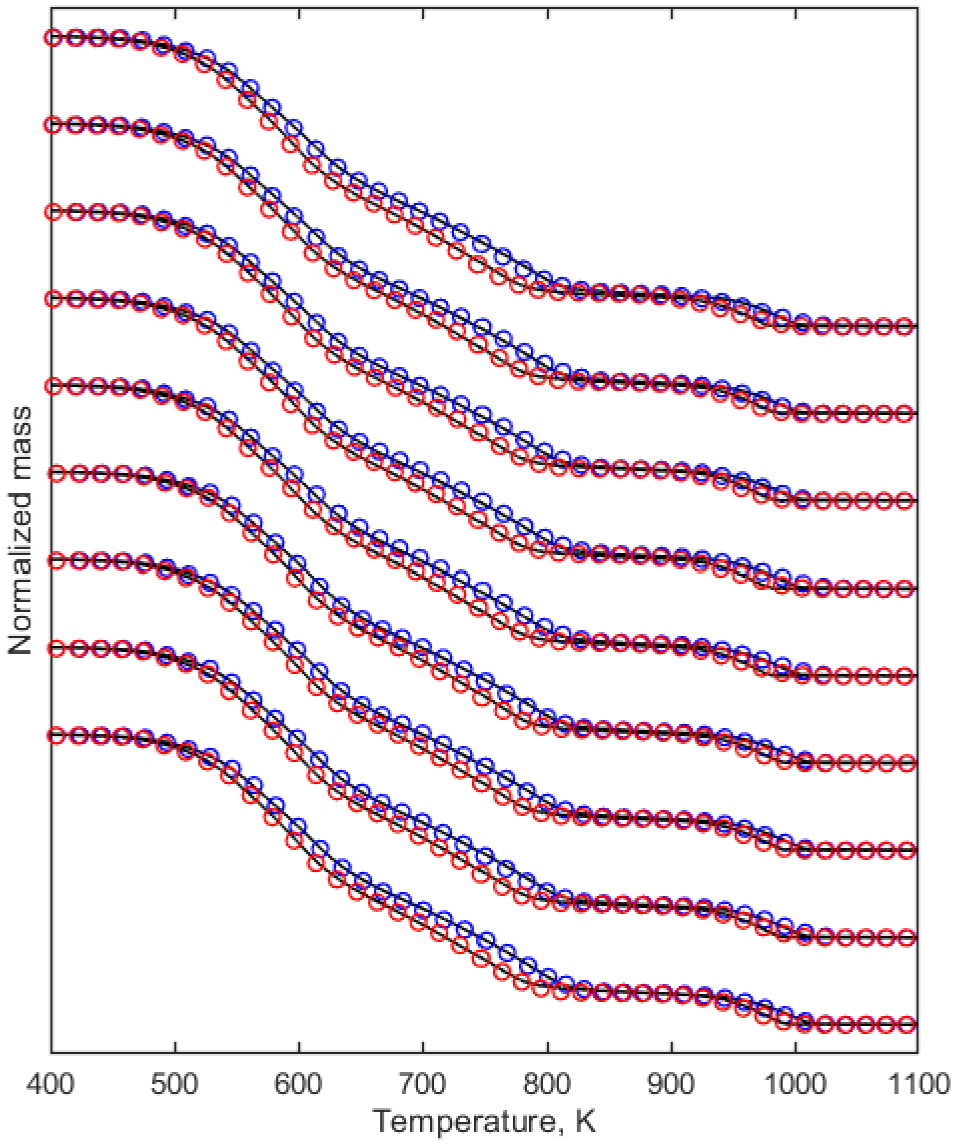

Figure S1: Nine repetitions of the combustion of the sewage sludge. Black curves represent the measured data (10 and 20 K/min). The red and blue circles represent the calculated thermograms resulting from the TGA evaluation algorithm with heating rates of 10 and 20 K/min. Each curve runs from unity to zero. Curves are stacked for convenient display.

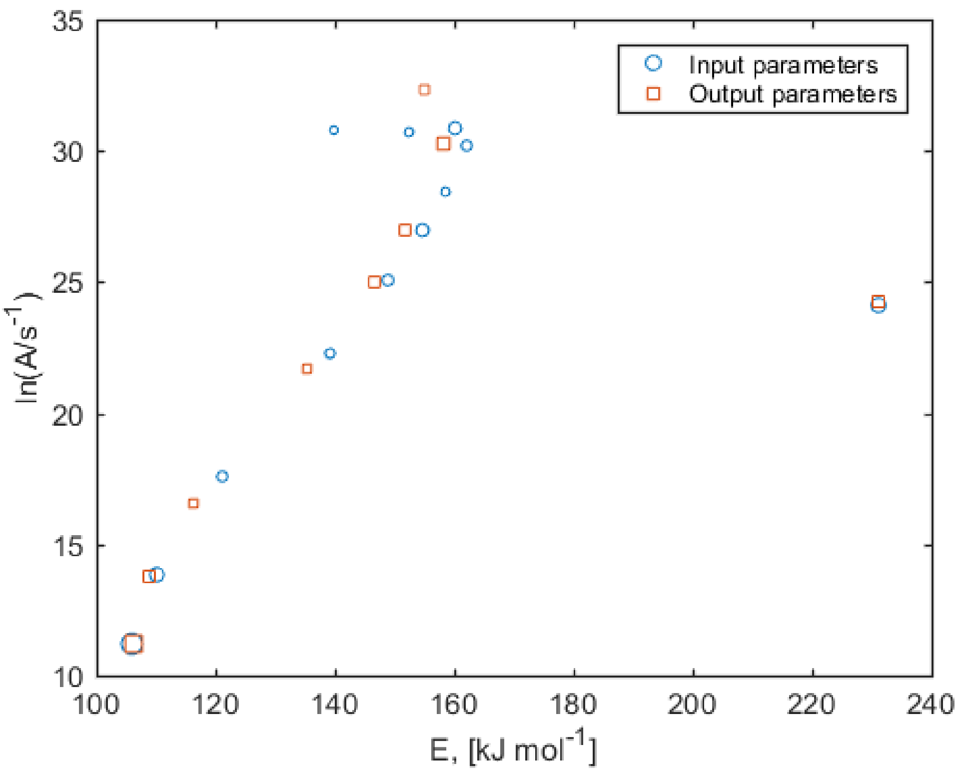

Figure S2: Input and output parameters of a sewage sludge combustion experiment including 12 overlapping reactions. The input parameters are determined by the TGA evaluation algorithm. The data resulted from TG experiments (heating rates: 10 and 20 K/min) with sewage sludge. The input parameters are further used to calculate synthetic thermograms using equation 7. In turn, the TGA evaluation algorithm is used retrieve the kinetic parameters (activation energy (E) and pre-exponential factor (A)) from the synthetic thermograms again. These are called ‘output parameters’.

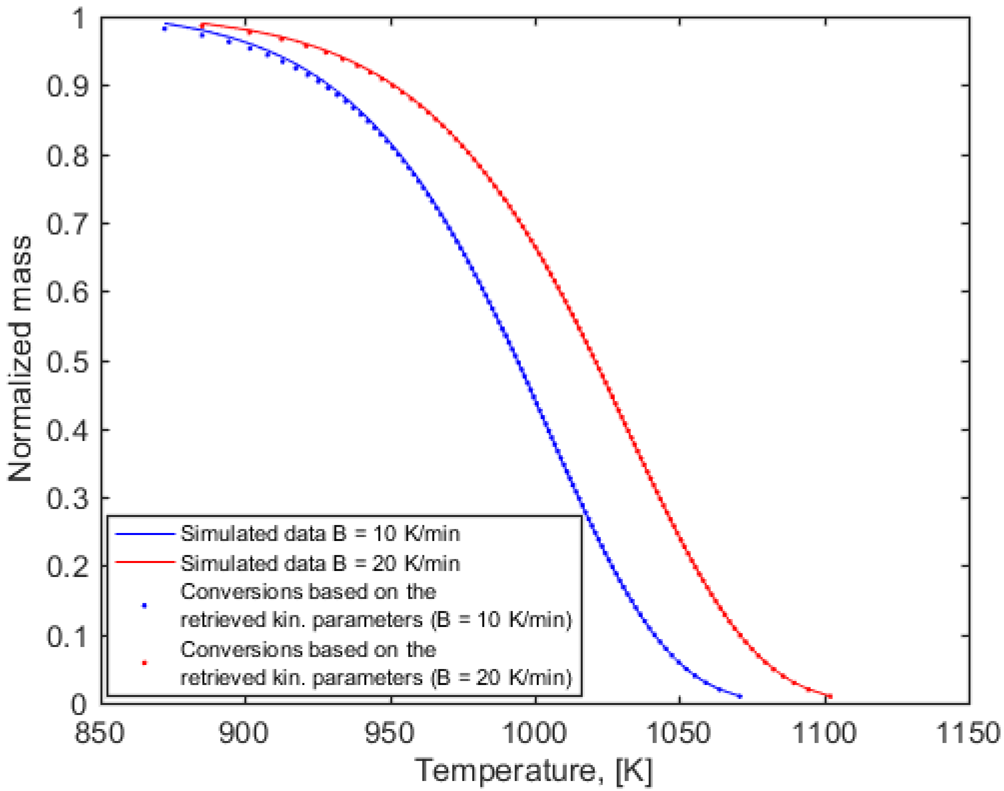

Figure S1: Simulated data (blue and red lines) with $E = 200$ kJ/mol and $A = 10^{8}\ \mathrm{s}^{-1}$. Conversions (blue and red dots) based on the retrieved kinetic parameters, $E = 201.42$ kJ/mol and $A = 10^{8.0712}\ s^{-1}$. Relative errors are 0.7% for E and 0.9% for A.

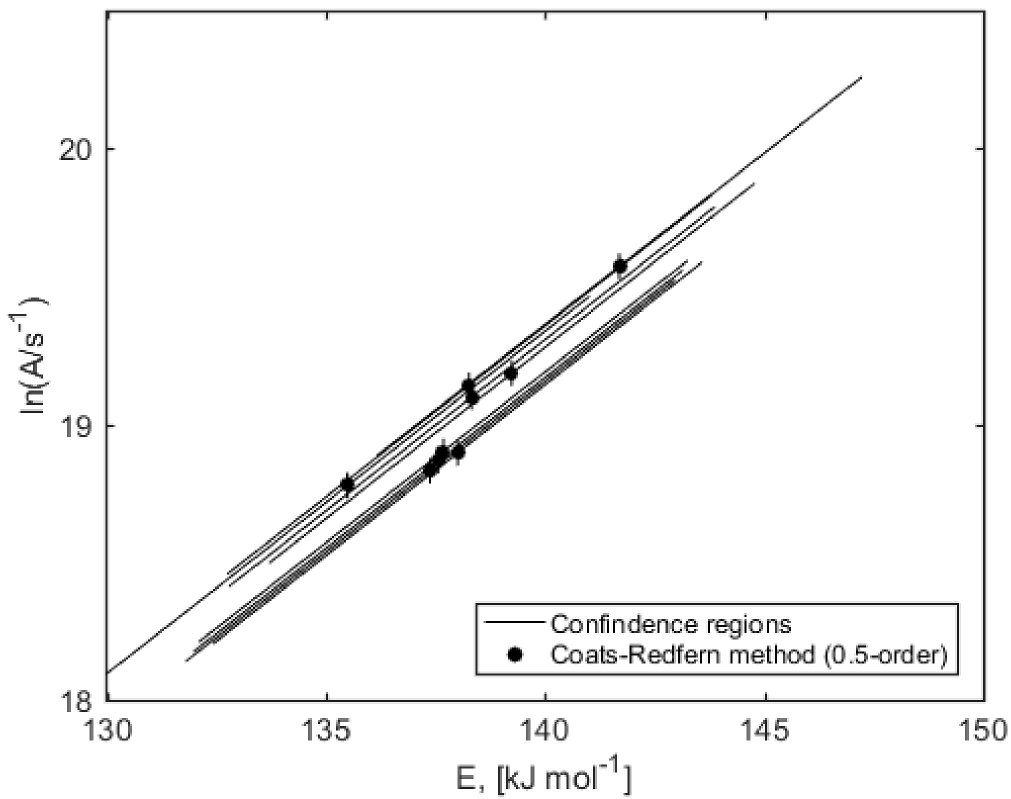

Figure S2: Confidence regions resulting from the analysis of the TG recorded for P1 applying the Coats-Redfern method and using a pseudo 0.5-order reaction model. The triangles represent the calculated values and the black lines define the regions of maximal statistical variations.