Supplementary Files:

Adsorption Rate Equation:

$$A + S \underset{k_{-A}}{\overset{k_A}{\leftrightharpoons}} A.S \tag{S1}$$

$$r_{ADS} = k_A C_A C_S - k_{-A} C_{A.S} \tag{S2}$$

$$K_A = \frac{k_A}{k_{-A}} \tag{S3}$$

$$r_{ADS} = k_A \left[C_A C_S - \frac{C_{A.S}}{K_A} \right] \tag{S4}$$

Surface Reaction Rate Equation:

$$A.S \underset{k_{-s}}{\overset{k_s}{\leftrightharpoons}} B.S + C \tag{S5}$$

$$r_S = k_s C_{A.S} - k_{-s} C_{B.S} C_C \tag{S6}$$

$$K_S = \frac{k_s}{k_{-s}} \tag{S7}$$

$$r_S = k_s \left[C_{A.S} - \frac{C_{B.S} C_C}{K_S} \right] \tag{S8}$$

Desorption Rate Equation:

$$B.S \underset{k_{-d}}{\overset{k_d}{\leftrightharpoons}} B + S \tag{S9}$$

$$r_D = k_d C_{B.S} - k_{-d} C_B C_S \tag{S10}$$

$$K_D = \frac{k_d}{k_{-d}} \tag{S11}$$

$$r_D = k_d \left[C_{B.S} - \frac{C_B C_S}{K_D} \right] \tag{S12}$$

If Adsorption of RCOOH is the determining step then

$$r_S = r_D = 0 \tag{S13}$$

$$r_S = k_s \left[C_{A.S} - \frac{C_{B.S} C_C}{K_S} \right] = 0 \tag{S14}$$

$$C_{A.S} = \frac{C_{B.S} C_C}{K_S} \tag{S15}$$

$$r_D = k_d \left[C_{B.S} - \frac{C_B C_S}{K_D} \right] = 0 \tag{S16}$$

$$K_B = \frac{1}{K_D} \tag{S17}$$

$$C_{B.S} = K_B C_B C_S \tag{S18}$$

$$C_{A.S} = \frac{K_B C_B C_S C_C}{K_S} \tag{S19}$$

Put them in Adsorption equation

$$r_{ADS} = k_A \left[C_A C_S - \frac{K_B C_B C_S C_C}{K_A K_S} \right] \tag{S20}$$

$$r_{ADS} = k_A \left[C_A - \frac{K_B C_B C_C}{K_A K_S} \right] C_S \tag{S21}$$

$$\text{Totalsites} = \text{Vacantsites} + \text{Occupiedsites} \tag{S22}$$

$$C_T = C_S + C_{A.S} + C_{B.S} \tag{S23}$$

$$C_T = C_S + \frac{K_B C_B C_S C_C}{K_S} + K_B C_B C_S \quad (S24)$$

$$C_T = C_S \left(1 + \frac{K_B C_B C_C}{K_S} + K_B C_B\right) \quad (S25)$$

$$C_S = \frac{C_T}{\left(1 + \frac{K_B C_B C_C}{K_S} + K_B C_B\right)} \quad (S26)$$

$$r_{ADS} = \frac{k_A C_T \left[C_A - \frac{K_B C_B C_C}{K_A K_S}\right]}{\left(1 + \frac{K_B C_B C_C}{K_S} + K_B C_B\right)} \quad (S27)$$

$$K = \frac{K_A K_S}{K_B} \quad (S28)$$

$$K_R = \frac{K_B}{K_S} \quad (S29)$$

$$r_{ADS} = \frac{k_A \left[C_A - \frac{C_B C_C}{K}\right]}{(1 + K_R C_B C_C + K_B C_B)} \quad (S30)$$

If Surface Reaction of RCOOH.S is the determining step then

$$r_{ADS} = r_D = 0 \quad (S31)$$

$$r_{ADS} = k_A \left[C_A C_S - \frac{C_{A.S}}{K_A}\right] = 0 \quad (S32)$$

$$C_{A.S} = K_A C_A C_S \quad (S33)$$

$$r_D = k_d \left[C_{B.S} - \frac{C_B C_S}{K_D}\right] = 0 \quad (S34)$$

$$C_{B.S} = K_B C_B C_S \quad (S35)$$

Put them in the Surface Reaction equation

$$r_S = k_s \left[K_A C_A C_S - \frac{K_B C_B C_S C_C}{K_S}\right] \quad (S36)$$

$$r_S = k_s C_S \left[K_A C_A - \frac{K_B C_B C_C}{K_S}\right] \quad (S37)$$

$$\text{Total sites} = \text{Vacant sites} + \text{Occupied sites} \quad (S38)$$

$$C_T = C_S + C_{A.S} + C_{B.S} \quad (S39)$$

$$C_T = C_S + K_A C_A C_S + K_B C_B C_S (36) \quad (S40)$$

$$C_T = C_S (1 + K_A C_A + K_B C_B) (37) \quad (S41)$$

$$C_S = \frac{C_T}{(1 + K_A C_A + K_B C_B)} \quad (S42)$$

$$r_S = \frac{k_s C_T \left[K_A C_A - \frac{K_B C_B C_C}{K_S}\right]}{(1 + K_A C_A + K_B C_B)} \quad (S43)$$

$$r_S = \frac{k_s C_T K_A \left[C_A - \frac{K_B C_B C_C}{K_A K_S}\right]}{(1 + K_A C_A + K_B C_B)} \quad (S44)$$

$$r_S = \frac{k \left[C_A - \frac{C_B C_C}{K}\right]}{(1 + K_A C_A + K_B C_B)} \quad (S45)$$

If Desorption of RH.S is the determining step then

$$r_{ADS} = r_S = 0 \quad (S46)$$

$$r_{ADS} = k_A \left[C_A C_S - \frac{C_{A.S}}{K_A}\right] = 0 \quad (S47)$$

$$C_{A.S} = K_A C_A C_S \quad (S48)$$

$$r_S = k_s \left[C_{A.S} - \frac{C_{B.S} C_C}{K_S}\right] = 0 \quad (S49)$$

$$C_{B.S} = \frac{C_{A.S} K_S}{C_C} \tag{S50}$$

$$C_{B.S} = \frac{K_A C_A C_S K_S}{C_C} \tag{S51}$$

$$r_D = k_d C_S \left[\frac{K_A C_A K_S}{C_C} - \frac{C_B}{K_D}\right] \tag{S52}$$

$$r_D = k_d C_S K_A K_S \left[\frac{C_A}{C_C} - \frac{C_B}{K_P}\right] \tag{S53}$$

$$\text{Total sites} = \text{Vacant sites} + \text{Occupied sites} \tag{S54}$$

$$C_T = C_S + C_{A.S} + C_{B.S} \tag{S55}$$

$$C_T = C_S + K_A C_A C_S + \frac{K_A C_A C_S K_S}{C_C} \tag{S56}$$

$$C_T = C_S \left(1 + K_A C_A + \frac{K_A C_A K_S}{C_C}\right) \tag{S57}$$

$$C_S = \frac{C_T}{\left(1 + K_A C_A + \frac{K_A C_A K_S}{C_C}\right)} \tag{S58}$$

$$r_D = \frac{k_d K_A K_S C_T \left[\frac{C_A}{C_C} - \frac{C_B}{K_P}\right]}{\left(1 + K_A C_A + \frac{K_A C_A K_S}{C_C}\right)} \tag{S59}$$

$$r_D = \frac{k \left[\frac{C_A}{C_C} - \frac{C_B}{K_P}\right]}{\left(1 + K_A C_A + \frac{K_R C_A}{C_C}\right)} \tag{S60}$$