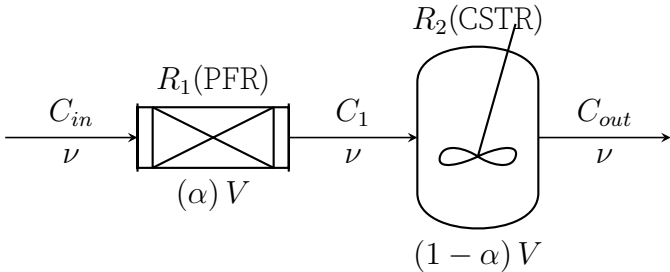

Modelo 1



C1

$$C_1 = E(t) = \frac{\sqrt{Pe}}{2 \sqrt{\pi (t/\alpha \tau)^3}} \exp \left(-\frac{Pe \alpha \tau}{4 t} \left(\frac{t}{\alpha \tau} - 1 \right)^2 \right)$$

C out

$$C_{out,i+1} = C_{out,i} + \frac{C_{1,i} - C_{out,i}}{(1 - \alpha) \tau} \Delta t$$

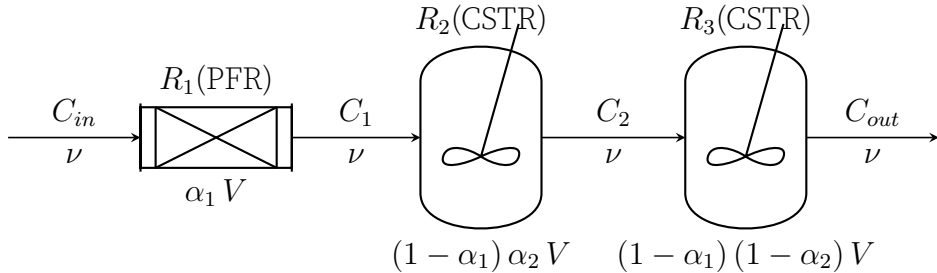
$$\nu C_1 = \nu C_{out} + (1 - \alpha) V \frac{dC_{out}}{dt} \Rightarrow$$

$$\Rightarrow C_1 = C_{out} + (1 - \alpha) \tau \frac{dC_{out}}{dt} \Rightarrow$$

$$\Rightarrow \frac{\Delta C_{out}}{\Delta t} = \frac{C_{out,i+1} - C_{out,i}}{\Delta t} = \frac{C_1 - C_{out}}{(1 - \alpha) \tau} \Rightarrow$$

$$\Rightarrow C_{out,i+1} = C_{out,i} + \frac{C_1 - C_{out}}{(1 - \alpha) \tau} \Delta t$$

Modelo 2



C2

$$C_{2,i+1} = C_{2,i} + \frac{C_{1,i} - C_{2,i}}{(1 - \alpha_1) \alpha_2 \tau} \Delta t$$

$$\nu C_1 = \nu C_2 + (1 - \alpha_1) \alpha_2 V \frac{dC_2}{dt} \Rightarrow$$

$$\Rightarrow C_1 = C_2 + (1 - \alpha_1) \alpha_2 \tau \frac{dC_2}{dt} \Rightarrow$$

$$\Rightarrow \frac{dC_2}{dt} = \frac{C_1 - C_2}{(1 - \alpha_1) \alpha_2 \tau} \Rightarrow$$

$$\Rightarrow \frac{\Delta C_2}{\Delta t} = \frac{C_{2,i+1} - C_{2,i}}{\Delta t} = \frac{C_{1,i} - C_{2,i}}{(1 - \alpha_1) \alpha_2 \tau} \Rightarrow$$

$$\Rightarrow C_{2,i+1} = C_{2,i} + \frac{C_{1,i} - C_{2,i}}{(1 - \alpha_1) \alpha_2 \tau} \Delta t$$

C out

$$C_{out,i+1} = C_{out,i} + \frac{C_{2,i} - C_{out,i}}{(1 - \alpha_1)(1 - \alpha_2) \tau} \Delta t$$

$$\nu C_2 = \nu C_{out} + (1 - \alpha_1)(1 - \alpha_2) V \frac{dC_{out}}{dt} \implies$$

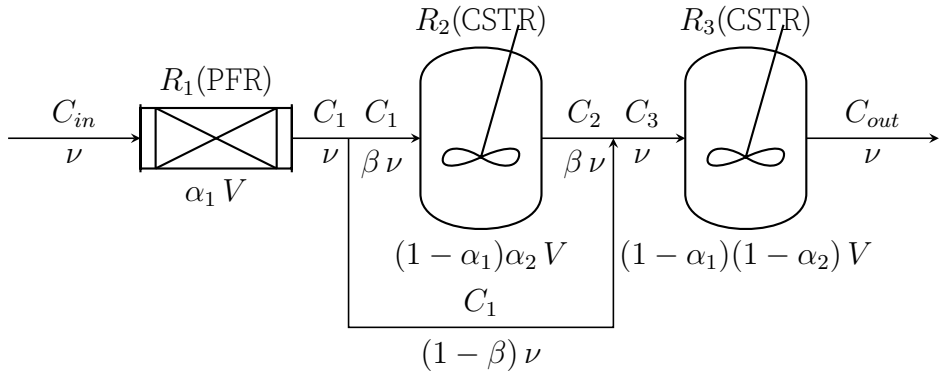
$$\implies C_2 = C_{out} + (1 - \alpha_1)(1 - \alpha_2) \tau \frac{dC_{out}}{dt} \implies$$

$$\implies \frac{dC_{out}}{dt} = \frac{C_2 - C_{out}}{(1 - \alpha_1)(1 - \alpha_2) \tau} \implies$$

$$\implies \frac{\Delta C_{out}}{\Delta t} = \frac{C_{out,i+1} - C_{out,i}}{\Delta t} = \frac{C_{2,i} - C_{out,i}}{(1 - \alpha_1)(1 - \alpha_2) \tau} \implies$$

$$\implies C_{out,i+1} = C_{out,i} + \frac{C_{2,i} - C_{out,i}}{(1 - \alpha_1)(1 - \alpha_2) \tau} \Delta t$$

Modelo 2.1



C2

$$C_{2,i+1} = C_{2,i} + \frac{C_{1,i} - C_{2,i}}{\tau} \frac{\beta}{(1 - \alpha_1) (1 - \alpha_1) \alpha_2} \Delta t$$

$$\beta \nu C_1 = \beta \nu C_2 + (1 - \alpha_1) \alpha_2 V \frac{dC_2}{dt} \implies$$

$$\implies \beta C_1 = \beta C_2 + (1 - \alpha_1) \alpha_2 \tau \frac{dC_2}{dt} \implies$$

$$\implies \frac{dC_2}{dt} = \frac{C_1 - C_2}{(1 - \alpha_1) \alpha_2 \tau} \beta \implies$$

$$\implies \frac{\Delta C_2}{\Delta t} = \frac{C_{2,i+1} - C_{2,i}}{\Delta t} = \frac{C_{1,i} - C_{2,i}}{(1 - \alpha_1) \alpha_2 \tau} \beta \implies$$

$$\implies C_{2,i+1} = C_{2,i} + \frac{C_{1,i} - C_{2,i}}{(1 - \alpha_1) \alpha_2 \tau} \beta \Delta t$$

C3

$$C_3 = \beta C_2 + (1 - \beta) C_1$$

$$\nu C_3 = \beta \nu C_2 + (1 - \beta) \nu C_1 \implies$$

$$\implies C_3 = \beta C_2 + (1 - \beta) C_1$$

C out

$$C_{out,i+1} = C_{out,i} + \frac{C_{out,i} - C_{3,i}}{(1 - \alpha_1)(1 - \alpha_2) \tau} \Delta t$$

$$\nu C_{out} = \nu C_3 + (1 - \alpha_1)(1 - \alpha_2) V \frac{dC_{out}}{dt} \implies$$

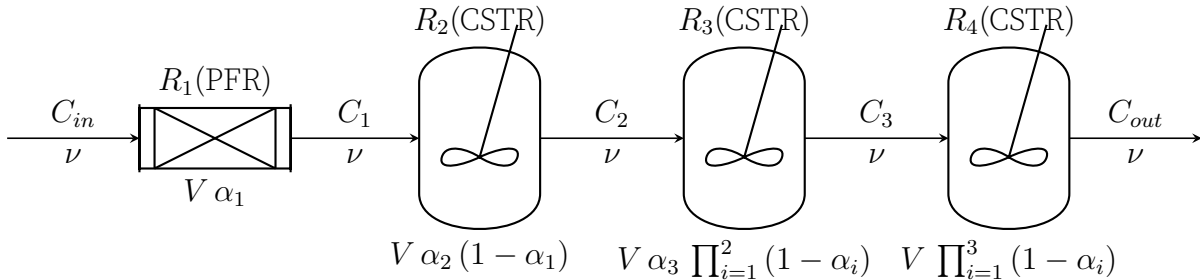
$$\implies C_{out} = C_3 + (1 - \alpha_1)(1 - \alpha_2) \tau \frac{dC_{out}}{dt} \implies$$

$$\implies \frac{dC_{out}}{dt} = \frac{C_{out} - C_3}{(1 - \alpha_1)(1 - \alpha_2) \tau} \implies$$

$$\implies \frac{\Delta C_{out}}{\Delta t} = \frac{C_{out,i+1} - C_{out,i}}{\Delta t} = \frac{C_{out,i} - C_{3,i}}{(1 - \alpha_1)(1 - \alpha_2) \tau} \implies$$

$$\implies C_{out,i+1} = C_{out,i} + \frac{C_{out,i} - C_{3,i}}{(1 - \alpha_1)(1 - \alpha_2) \tau} \Delta t$$

Modelo 3



C2

$$C_{2,i+1} = C_{2,i} + \frac{C_{1,i} - C_{2,i}}{(1 - \alpha_1) \alpha_2 \tau} \Delta t$$

$$\nu C_1 = \nu C_2 + (1 - \alpha_1) \alpha_2 V \frac{dC_2}{dt} \implies$$

$$\implies C_1 = C_2 + (1 - \alpha_1) \alpha_2 \tau \frac{dC_2}{dt} \implies$$

$$\implies \frac{dC_2}{dt} = \frac{C_1 - C_2}{(1 - \alpha_1) \alpha_2 \tau} \implies$$

$$\implies \frac{\Delta C_2}{\Delta t} = \frac{C_{2,i+1} - C_{2,i}}{\Delta t} = \frac{C_{1,i} - C_{2,i}}{(1 - \alpha_1) \alpha_2 \tau} \implies$$

$$\implies C_{2,i+1} = C_{2,i} + \frac{C_{1,i} - C_{2,i}}{(1 - \alpha_1) \alpha_2 \tau} \Delta t$$

C3

$$C_{3,i+1} = C_{3,i} + \frac{C_{2,i} - C_{3,i}}{\tau \alpha_3 \prod_{i=1}^2 (1 - \alpha_i)} \Delta t$$

$$\nu C_2 = \nu C_3 + \frac{dC_2}{dt} V \alpha_3 \prod_{i=1}^2 (1 - \alpha_i) \implies$$

$$\implies C_2 = C_3 + \frac{dC_3}{dt} \tau \alpha_3 \prod_{i=1}^2 (1 - \alpha_i) \implies$$

$$\implies \frac{dC_3}{dt} = \frac{C_2 - C_3}{\tau \alpha_3 \prod_{i=1}^2 (1 - \alpha_i)} \implies$$

$$\implies \frac{\Delta C_3}{\Delta t} = \frac{C_{3,i+1} - C_{3,i}}{\Delta t} = \frac{C_{2,i} - C_{3,i}}{\tau \alpha_3 \prod_{i=1}^2 (1 - \alpha_i)} \implies$$

$$\implies C_{3,i+1} = C_{3,i} + \frac{C_{2,i} - C_{3,i}}{\tau \alpha_3 \prod_{i=1}^2 (1 - \alpha_i)} \Delta t$$

Cout

$$C_{out,i+1} = C_{out,i} + \frac{C_{3,i} - C_{out,i}}{\tau \prod_{i=1}^3 (1 - \alpha_i)} \Delta t$$

$$\nu C_3 = \nu C_{out} + \frac{dC_{out}}{dt} V \prod_{i=1}^3 (1 - \alpha_i) \implies$$

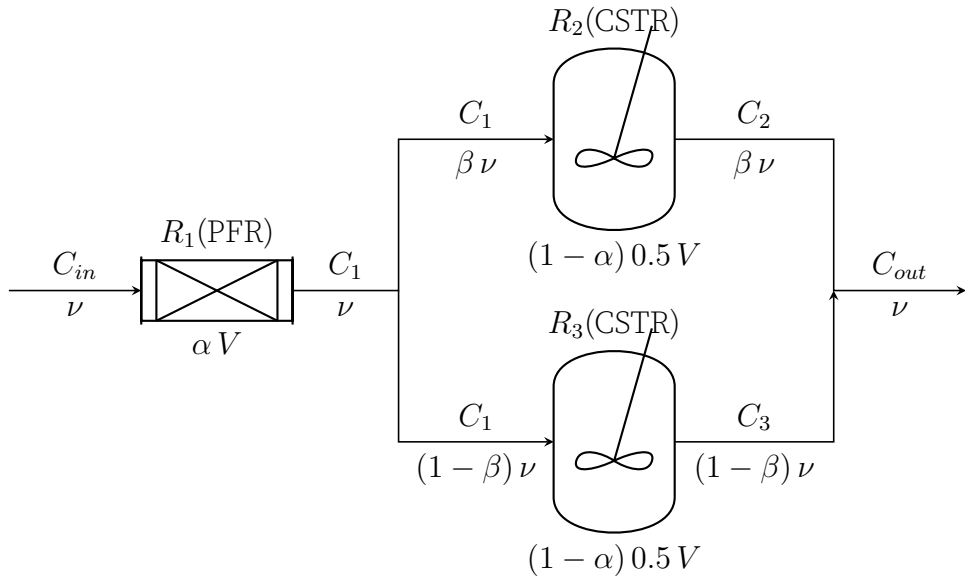
$$\implies C_3 = C_{out} + \frac{dC_{out}}{dt} \tau \prod_{i=1}^3 (1 - \alpha_i) \implies$$

$$\implies \frac{dC_{out}}{dt} = \frac{C_3 - C_{out}}{\tau \prod_{i=1}^3 (1 - \alpha_i)} \implies$$

$$\implies \frac{\Delta C_{out}}{\Delta t} = \frac{C_{out,i+1} - C_{out,i}}{\Delta t} = \frac{C_{3,i} - C_{out,i}}{\tau \prod_{i=1}^3 (1 - \alpha_i)} \implies$$

$$\implies C_{out,i+1} = C_{out,i} + \frac{C_{3,i} - C_{out,i}}{\tau \prod_{i=1}^3 (1 - \alpha_i)} \Delta t$$

Modelo 4



C2

$$C_{2,i+1} = C_{2,i} + \frac{C_{1,i} - C_{2,i}}{\tau} \frac{\beta}{(1 - \alpha) 0.5} \Delta t$$

$$\nu \beta C_1 = \nu \beta C_2 + (1 - \alpha) 0.5 V \frac{dC_2}{dt} \Rightarrow$$

$$\Rightarrow \beta C_1 = \beta C_2 + (1 - \alpha) 0.5 \tau \frac{dC_2}{dt} \Rightarrow$$

$$\Rightarrow \frac{dC_2}{dt} = \frac{C_1 - C_2}{\tau} \frac{\beta}{(1 - \alpha) 0.5} \Rightarrow$$

$$\Rightarrow \frac{\Delta C_2}{\Delta t} = \frac{C_{2,i+1} - C_{2,i}}{\Delta t} = \frac{C_{1,i} - C_{2,i}}{(1 - \alpha) 0.5 \tau} \beta \Rightarrow$$

$$\Rightarrow C_{2,i+1} = C_{2,i} + \frac{C_{1,i} - C_{2,i}}{\tau} \frac{\beta}{(1 - \alpha) 0.5} \Delta t$$

C3

$$C_{3,i+1} = C_{3,i} + \frac{C_{1,i} - C_{3,i}}{\tau} \frac{1 - \beta}{(1 - \alpha) 0.5} \Delta t$$

$$(1 - \beta) \nu C_1 = (1 - \beta) \nu C_3 + (1 - \alpha) 0.5 V \frac{dC_3}{dt} \Rightarrow$$

$$\Rightarrow (1 - \beta) C_1 = (1 - \beta) C_3 + (1 - \alpha) 0.5 \tau \frac{dC_3}{dt} \Rightarrow$$

$$\Rightarrow \frac{dC_3}{dt} = \frac{C_1 - C_3}{\tau} \frac{1 - \beta}{(1 - \alpha) 0.5} \Rightarrow$$

$$\Rightarrow \frac{\Delta C_3}{\Delta t} = \frac{C_{3,i+1} - C_{3,i}}{\Delta t} = \frac{C_{1,i} - C_{3,i}}{\tau} \frac{1 - \beta}{(1 - \alpha) 0.5} \Rightarrow$$

$$\Rightarrow C_{3,i+1} = C_{3,i} + \frac{C_{1,i} - C_{3,i}}{\tau} \frac{1 - \beta}{(1 - \alpha) 0.5} \Delta t$$

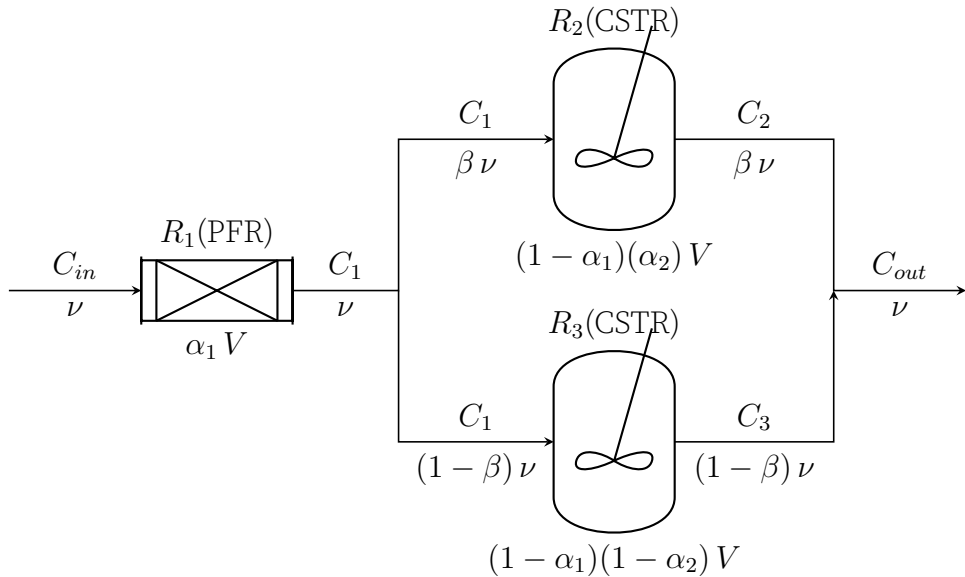
C out

$$C_{out} = \beta C_2 + (1 - \beta) C_3$$

$$\nu C_{out} = \beta \nu C_2 + (1 - \beta) \nu C_3 \implies$$

$$\implies C_{out} = \beta C_2 + (1 - \beta) C_3$$

Modelo 4.1



C2

$$C_{2,i+1} = C_{2,i} + \frac{C_{1,i} - C_{2,i}}{\tau} \frac{\beta}{(1 - \alpha_1)(\alpha_2)} \Delta t$$

$$C_1 \beta \nu = C_2 \beta \nu + (1 - \alpha_1)(\alpha_2) V \frac{dC_2}{dt} \Rightarrow$$

$$\Rightarrow C_1 \beta = C_2 \beta + (1 - \alpha_1)(\alpha_2) \tau \frac{dC_2}{dt} \Rightarrow$$

$$\Rightarrow \frac{dC_2}{dt} = \frac{C_1 - C_2}{\tau} \frac{\beta}{(1 - \alpha_1)(\alpha_2)} \Rightarrow$$

$$\Rightarrow \frac{\Delta C_2}{\Delta t} = \frac{C_{2,i+1} - C_{2,i}}{\Delta t} = \frac{C_{1,i} - C_{2,i}}{\tau} \frac{\beta}{(1 - \alpha_1)(\alpha_2)} \Rightarrow$$

$$\Rightarrow C_{2,i+1} = C_{2,i} + \frac{C_{1,i} - C_{2,i}}{\tau} \frac{\beta}{(1 - \alpha_1)(\alpha_2)} \Delta t$$

C3

$$C_{3,i+1} = C_{3,i} + \frac{C_1 - C_3}{\tau} \frac{1 - \beta}{(1 - \alpha_1)(1 - \alpha_2)} \Delta t$$

$$C_1 (1 - \beta) \nu = C_3 (1 - \beta) \nu + (1 - \alpha_1)(1 - \alpha_2) V \frac{dC_3}{dt} \Rightarrow$$

$$\Rightarrow C_1 (1 - \beta) = C_3 (1 - \beta) + (1 - \alpha_1)(1 - \alpha_2) \tau \frac{dC_3}{dt} \Rightarrow$$

$$\Rightarrow \frac{dC_3}{dt} = \frac{C_1 - C_3}{\tau} \frac{1 - \beta}{(1 - \alpha_1)(1 - \alpha_2)} \Rightarrow$$

$$\Rightarrow \frac{\Delta C_3}{\Delta t} = \frac{C_{3,i+1} - C_{3,i}}{\Delta t} = \frac{C_1 - C_3}{\tau} \frac{1 - \beta}{(1 - \alpha_1)(1 - \alpha_2)} \Rightarrow$$

$$\Rightarrow C_{3,i+1} = C_{3,i} + \frac{C_1 - C_3}{\tau} \frac{1 - \beta}{(1 - \alpha_1)(1 - \alpha_2)} \Delta t$$

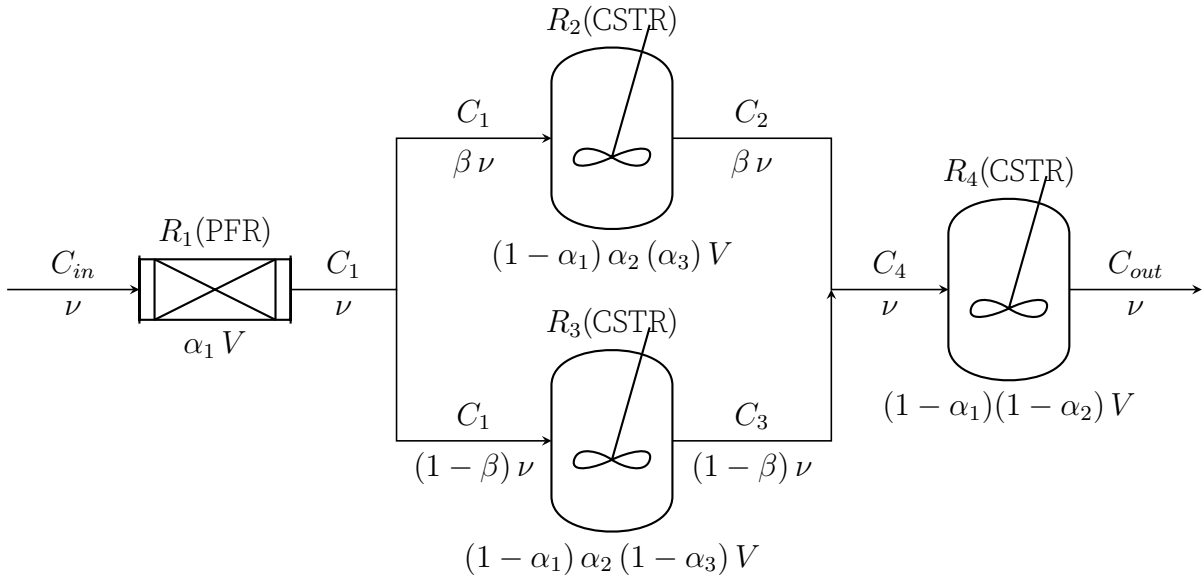
C out

$$C_{out} = C_2 (\beta) + C_3 (1 - \beta)$$

$$C_{out} \nu = C_2 (\beta) \nu + C_3 (1 - \beta) \nu \implies$$

$$\implies C_{out} = C_2 (\beta) + C_3 (1 - \beta)$$

Modelo 5



C2

$$C_{2,i+1} = C_{2,i} + \frac{C_{1,i} - C_{2,i}}{\tau} \frac{\beta}{(1 - \alpha_1) \alpha_2 (\alpha_3)} \Delta t$$

$$C_1 \beta \nu = C_2 \beta \nu + (1 - \alpha_1) \alpha_2 (\alpha_3) V \frac{dC_2}{dt} \Rightarrow$$

$$\Rightarrow C_1 \beta = C_2 \beta + (1 - \alpha_1) \alpha_2 (\alpha_3) \tau \frac{dC_2}{dt} \Rightarrow$$

$$\Rightarrow \frac{dC_2}{dt} = \frac{C_1 - C_2}{\tau} \frac{\beta}{(1 - \alpha_1) \alpha_2 (\alpha_3)} \Rightarrow$$

$$\Rightarrow \frac{\Delta C_2}{\Delta t} = \frac{C_{2,i+1} - C_{2,i}}{\Delta t} = \frac{C_{1,i} - C_{2,i}}{\tau} \frac{\beta}{(1 - \alpha_1) \alpha_2 (\alpha_3)} \Rightarrow$$

$$\Rightarrow C_{2,i+1} = C_{2,i} + \frac{C_{1,i} - C_{2,i}}{\tau} \frac{\beta}{(1 - \alpha_1) \alpha_2 (\alpha_3)} \Delta t$$

C3

$$C_{3,i+1} = C_{3,i} + \frac{C_1 - C_3}{\tau} \frac{1 - \beta}{(1 - \alpha_1) \alpha_2 (1 - \alpha_3)} \Delta t$$

$$C_1 (1 - \beta) \nu = C_3 (1 - \beta) \nu + (1 - \alpha_1) \alpha_2 (1 - \alpha_3) V \frac{dC_3}{dt} \Rightarrow$$

$$\Rightarrow C_1 (1 - \beta) = C_3 (1 - \beta) + (1 - \alpha_1) \alpha_2 (1 - \alpha_3) \tau \frac{dC_3}{dt} \Rightarrow$$

$$\Rightarrow \frac{dC_3}{dt} = \frac{C_1 - C_3}{\tau} \frac{1 - \beta}{(1 - \alpha_1) \alpha_2 (1 - \alpha_3)} \Rightarrow$$

$$\Rightarrow \frac{\Delta C_3}{\Delta t} = \frac{C_{3,i+1} - C_{3,i}}{\Delta t} = \frac{C_{1,i} - C_{3,i}}{\tau} \frac{1 - \beta}{(1 - \alpha_1) \alpha_2 (1 - \alpha_3)} \Rightarrow$$

$$\Rightarrow C_{3,i+1} = C_{3,i} + \frac{C_{1,i} - C_{3,i}}{\tau} \frac{1 - \beta}{(1 - \alpha_1) \alpha_2 (1 - \alpha_3)} \Delta t$$

C4

$$C_4 = C_2 (\beta) + C_3 (1 - \beta)$$

$$C_4 \nu = C_2 (\beta) \nu + C_3 (1 - \beta) \nu \implies$$

$$\implies C_4 = C_2 (\beta) + C_3 (1 - \beta)$$

C out

$$C_{out,i+1} = C_{out,i} + \frac{C_{4,i} - C_{out,i}}{(1 - \alpha_1)(1 - \alpha_2) \tau} \Delta t$$

$$C_4 \nu = C_{out} \nu + (1 - \alpha_1)(1 - \alpha_2) V \frac{dC_{out}}{dt} \Rightarrow$$

$$\Rightarrow C_4 = C_{out} + (1 - \alpha_1)(1 - \alpha_2) \tau \frac{dC_{out}}{dt} \Rightarrow$$

$$\Rightarrow \frac{dC_{out}}{dt} = \frac{C_4 - C_{out}}{(1 - \alpha_1)(1 - \alpha_2) \tau} \Rightarrow$$

$$\Rightarrow \frac{\Delta C_{out}}{\Delta t} = \frac{C_{out,i+1} - C_{out,i}}{\Delta t} = \frac{C_{4,i} - C_{out,i}}{(1 - \alpha_1)(1 - \alpha_2) \tau} \Rightarrow$$

$$\Rightarrow C_{out,i+1} = C_{out,i} + \frac{C_{4,i} - C_{out,i}}{(1 - \alpha_1)(1 - \alpha_2) \tau} \Delta t$$

Art

