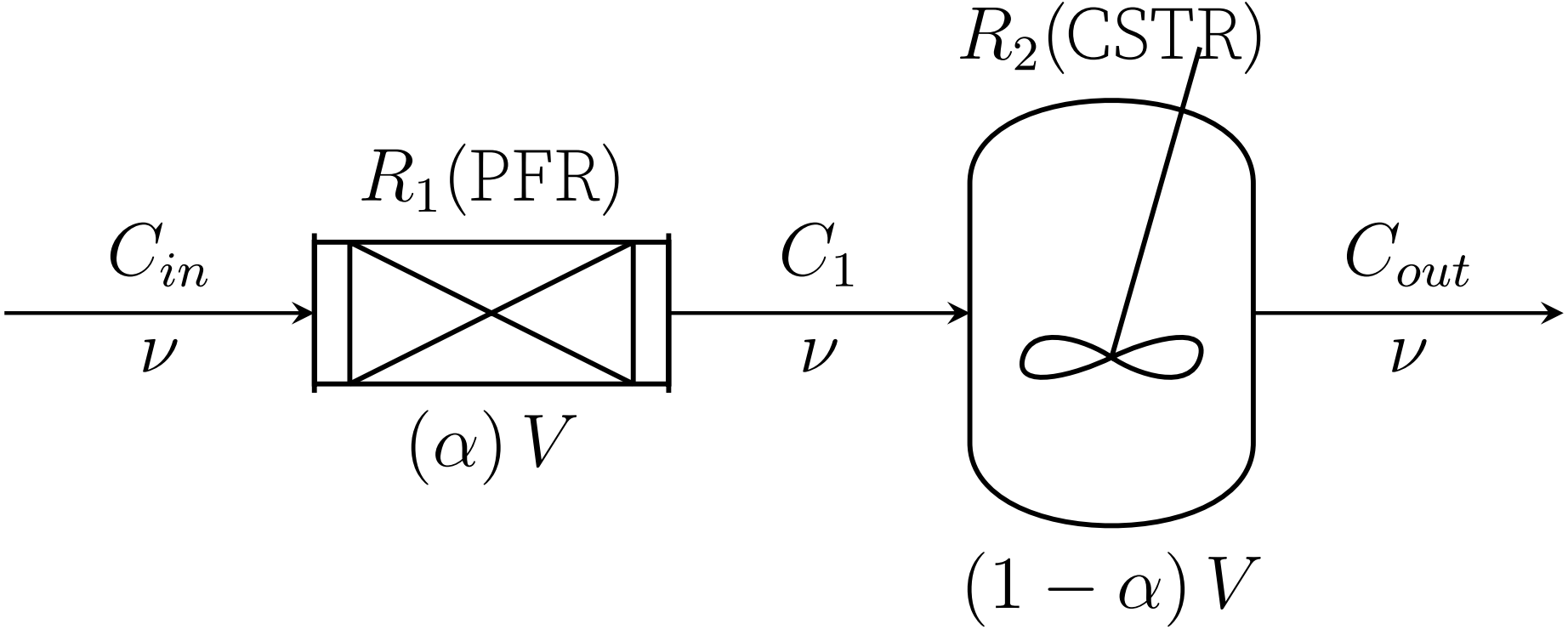
Modelo 1


R_2(CSTR)
R_1(PFR)
C_{in}
ν
$(\alpha)\,V$
C_1
ν
C_{out}
ν
$(1-\alpha)\,V$

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

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

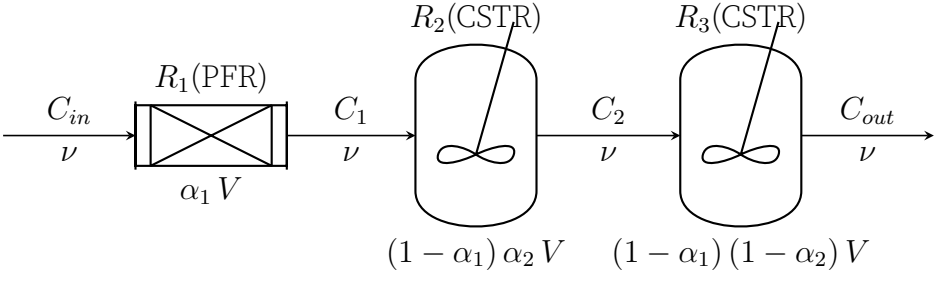
$$\nu\, C_1 = \nu\, C_{out} + (1-\alpha)\, V\, \frac{\mathrm{d}C_{out}}{\mathrm{d}t} \implies$$

$$\implies C_1 = C_{out} + (1-\alpha)\,\tau\, \frac{\mathrm{d}C_{out}}{\mathrm{d}t} \implies$$

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

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

Modelo 2


R_2(CSTR)
R_3(CSTR)
R_1(PFR)
C_{in}
ν
$\alpha_1 V$
C_1
ν
C_2
ν
C_{out}
ν
$(1-\alpha_1)\,\alpha_2\,V$
$(1-\alpha_1)\,(1-\alpha_2)\,V$

C2

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

$$\nu\, C_1 = \nu\, C_2 + (1-\alpha_1)\,\alpha_2\, V\, \frac{\mathrm{d}C_2}{\mathrm{d}t} \implies$$

$$\implies C_1 = C_2 + (1-\alpha_1)\,\alpha_2\,\tau\, \frac{\mathrm{d}C_2}{\mathrm{d}t} \implies$$

$$\implies \frac{\mathrm{d}C_2}{\mathrm{d}t} = \frac{C_1 - C_2}{(1-\alpha_1)\,\alpha_2\,\tau} \implies$$

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

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

C out

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

$$\nu\, C_2 = \nu\, C_{out} + (1-\alpha_1)(1-\alpha_2)\, V\, \frac{\mathrm{d}C_{out}}{\mathrm{d}t} \implies$$

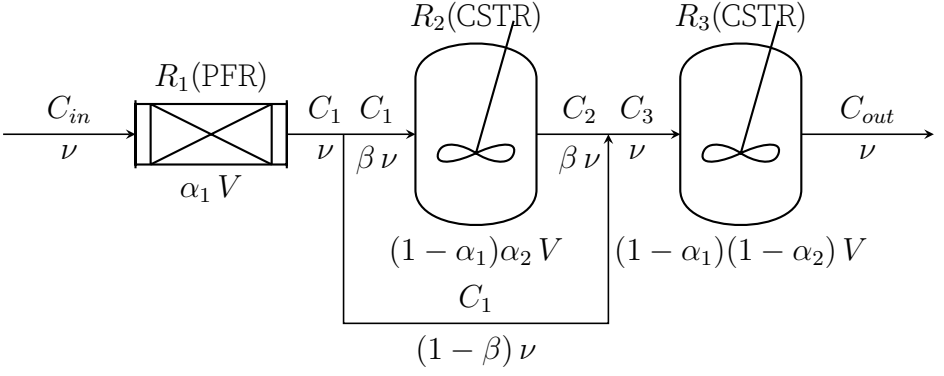
$$\implies C_2 = C_{out} + (1-\alpha_1)(1-\alpha_2)\,\tau\, \frac{\mathrm{d}C_{out}}{\mathrm{d}t} \implies$$

$$\implies \frac{\mathrm{d}C_{out}}{\mathrm{d}t} = \frac{C_2 - C_{out}}{(1-\alpha_1)(1-\alpha_2)\,\tau} \implies$$

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

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

Modelo 2.1


R_2(CSTR)
R_3(CSTR)
R_1(PFR)
C_{in}
ν
$\alpha_1 V$
C_1
ν
C_1
$\beta\,\nu$
$(1-\alpha_1)\alpha_2 V$
C_2
$\beta\,\nu$
C_3
ν
$(1-\alpha_1)(1-\alpha_2) V$
C_{out}
ν
C_1
$(1-\beta)\,\nu$

C2

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

$$\beta \nu C_1 = \beta \nu C_2 + (1-\alpha_1)\alpha_2 V \frac{\mathrm{d}C_2}{\mathrm{d}t} \implies$$

$$\implies \beta C_1 = \beta C_2 + (1-\alpha_1)\alpha_2 \tau \frac{\mathrm{d}C_2}{\mathrm{d}t} \implies$$

$$\implies \frac{\mathrm{d}C_2}{\mathrm{d}t} = \frac{C_1 - C_2}{(1-\alpha_1)\alpha_2 \tau} \beta \implies$$

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

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

C3

$$\boldsymbol{C_3 = \beta\, C_2 + (1 - \beta)\, C_1}$$

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

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

C out

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

$$\nu\, C_{out} = \nu\, C_3 + (1-\alpha_1)(1-\alpha_2)\, V\, \frac{\mathrm{d}C_{out}}{\mathrm{d}t} \implies$$

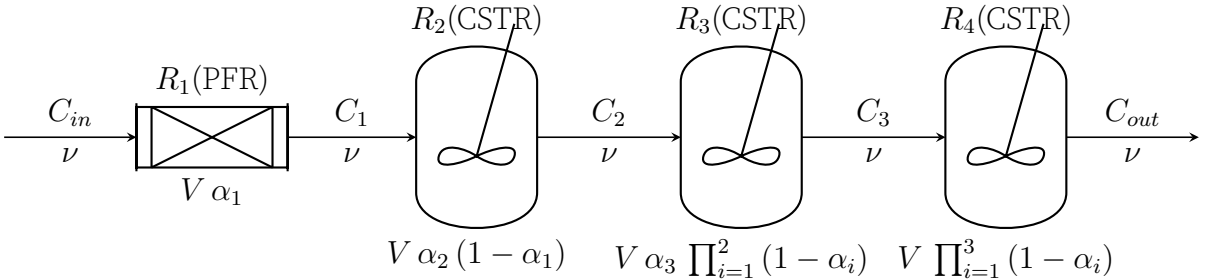
$$\implies C_{out} = C_3 + (1-\alpha_1)(1-\alpha_2)\,\tau\, \frac{\mathrm{d}C_{out}}{\mathrm{d}t} \implies$$

$$\implies \frac{\mathrm{d}C_{out}}{\mathrm{d}t} = \frac{C_{out} - C_3}{(1-\alpha_1)(1-\alpha_2)\,\tau} \implies$$

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

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

Modelo 3


R_1(PFR)
R_2(CSTR)
R_3(CSTR)
R_4(CSTR)
C_{in}
ν
$V\,\alpha_1$
C_1
ν
$V\,\alpha_2\,(1-\alpha_1)$
C_2
ν
$V\,\alpha_3\,\prod_{i=1}^{2}(1-\alpha_i)$
C_3
ν
$V\,\prod_{i=1}^{3}(1-\alpha_i)$
C_{out}
ν

C2

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

$$\nu\, C_1 = \nu\, C_2 + (1-\alpha_1)\,\alpha_2\, V\, \frac{\mathrm{d}C_2}{\mathrm{d}t} \implies$$

$$\implies C_1 = C_2 + (1-\alpha_1)\,\alpha_2\,\tau\, \frac{\mathrm{d}C_2}{\mathrm{d}t} \implies$$

$$\implies \frac{\mathrm{d}C_2}{\mathrm{d}t} = \frac{C_1 - C_2}{(1-\alpha_1)\,\alpha_2\,\tau} \implies$$

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

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

C3

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

$$\nu\, C_2 = \nu\, C_3 + \frac{\mathrm{d}C_2}{\mathrm{d}t}\, V\, \alpha_3 \prod_{i=1}^{2}(1-\alpha_i) \implies$$

$$\implies C_2 = C_3 + \frac{\mathrm{d}C_3}{\mathrm{d}t}\, \tau\, \alpha_3 \prod_{i=1}^{2}(1-\alpha_i) \implies$$

$$\implies \frac{\mathrm{d}C_3}{\mathrm{d}t} = \frac{C_2 - C_3}{\tau\,\alpha_3 \prod_{i=1}^{2}(1-\alpha_i)} \implies$$

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

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

Cout

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

$$\nu \, C_3 = \nu \, C_{out} + \frac{\mathrm{d}C_{out}}{\mathrm{d}t} \, V \prod_{i=1}^{3} (1 - \alpha_i) \implies$$

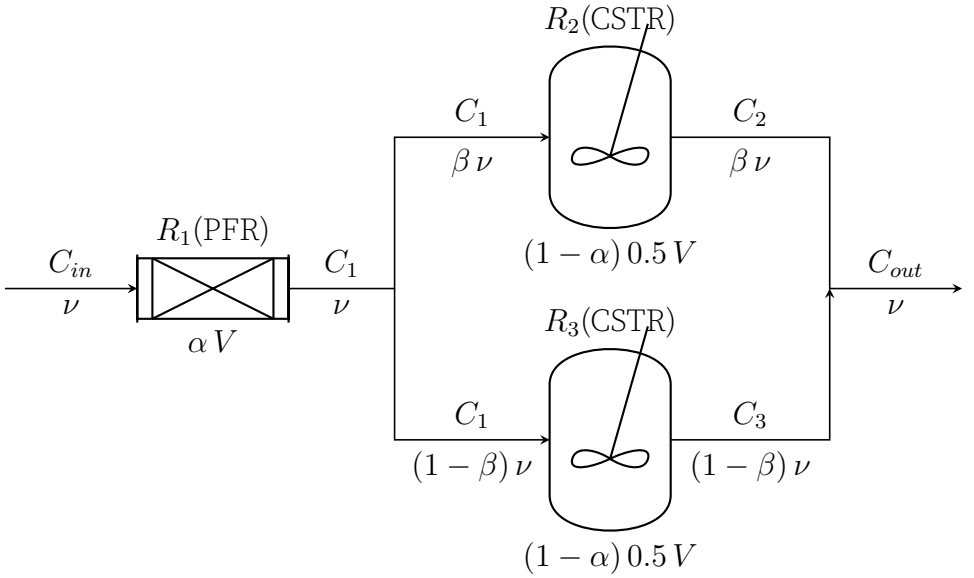
$$\implies C_3 = C_{out} + \frac{\mathrm{d}C_{out}}{\mathrm{d}t} \, \tau \prod_{i=1}^{3} (1 - \alpha_i) \implies$$

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

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

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

Modelo 4


R_2(CSTR)
C_1
$\beta\,\nu$
C_2
$\beta\,\nu$
$(1-\alpha)\,0.5\,V$
C_{in}
ν
R_1(PFR)
$\alpha\,V$
C_1
ν
C_{out}
ν
R_3(CSTR)
C_1
$(1-\beta)\,\nu$
C_3
$(1-\beta)\,\nu$
$(1-\alpha)\,0.5\,V$

C2

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

$$\nu\,\beta\,C_1 = \nu\,\beta\,C_2 + (1-\alpha)\,0.5\,V\,\frac{\mathrm{d}C_2}{\mathrm{d}t} \implies$$

$$\implies \beta\,C_1 = \beta\,C_2 + (1-\alpha)\,0.5\,\tau\,\frac{\mathrm{d}C_2}{\mathrm{d}t} \implies$$

$$\implies \frac{\mathrm{d}C_2}{\mathrm{d}t} = \frac{C_1 - C_2}{\tau}\,\frac{\beta}{(1-\alpha)\,0.5} \implies$$

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

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

C3

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

$$(1-\beta)\,\nu\,C_1 = (1-\beta)\,\nu\,C_3 + (1-\alpha)\,0.5\,V\,\frac{\mathrm{d}C_3}{\mathrm{d}t} \implies$$

$$\implies (1-\beta)\,C_1 = (1-\beta)\,C_3 + (1-\alpha)\,0.5\,\tau\,\frac{\mathrm{d}C_3}{\mathrm{d}t} \implies$$

$$\implies \frac{\mathrm{d}C_3}{\mathrm{d}t} = \frac{C_1 - C_3}{\tau}\,\frac{1-\beta}{(1-\alpha)\,0.5} \implies$$

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

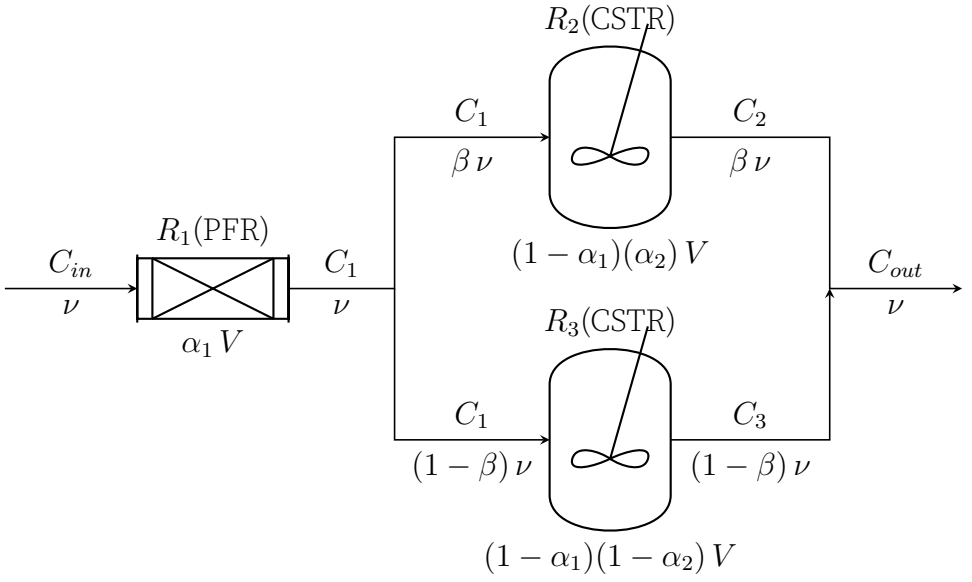
$$\implies C_{3,i+1} = C_{3,i} + \frac{C_{1,i} - C_{3,i}}{\tau}\,\frac{1-\beta}{(1-\alpha)\,0.5}\,\Delta t$$

C out

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

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

Modelo 4.1


R_2(CSTR)
C_1
$\beta\,\nu$
C_2
$\beta\,\nu$
$(1-\alpha_1)(\alpha_2)\,V$
C_{in}
ν
R_1(PFR)
$\alpha_1\,V$
C_1
ν
C_{out}
ν
R_3(CSTR)
C_1
$(1-\beta)\,\nu$
C_3
$(1-\beta)\,\nu$
$(1-\alpha_1)(1-\alpha_2)\,V$

C2

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

$$C_1 \beta \nu = C_2 \beta \nu + (1-\alpha_1)(\alpha_2) V \frac{\mathrm{d}C_2}{\mathrm{d}t} \implies$$

$$\implies C_1 \beta = C_2 \beta + (1-\alpha_1)(\alpha_2) \tau \frac{\mathrm{d}C_2}{\mathrm{d}t} \implies$$

$$\implies \frac{\mathrm{d}C_2}{\mathrm{d}t} = \frac{C_1 - C_2}{\tau} \frac{\beta}{(1-\alpha_1)(\alpha_2)} \implies$$

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

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

C3

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

$$C_1 (1-\beta)\, \nu = C_3 (1-\beta)\, \nu + (1-\alpha_1)(1-\alpha_2)\, V \frac{\mathrm{d}C_3}{\mathrm{d}t} \implies$$

$$\implies C_1 (1-\beta) = C_3 (1-\beta) + (1-\alpha_1)(1-\alpha_2)\, \tau \frac{\mathrm{d}C_3}{\mathrm{d}t} \implies$$

$$\implies \frac{\mathrm{d}C_3}{\mathrm{d}t} = \frac{C_1 - C_3}{\tau} \frac{1-\beta}{(1-\alpha_1)(1-\alpha_2)} \implies$$

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

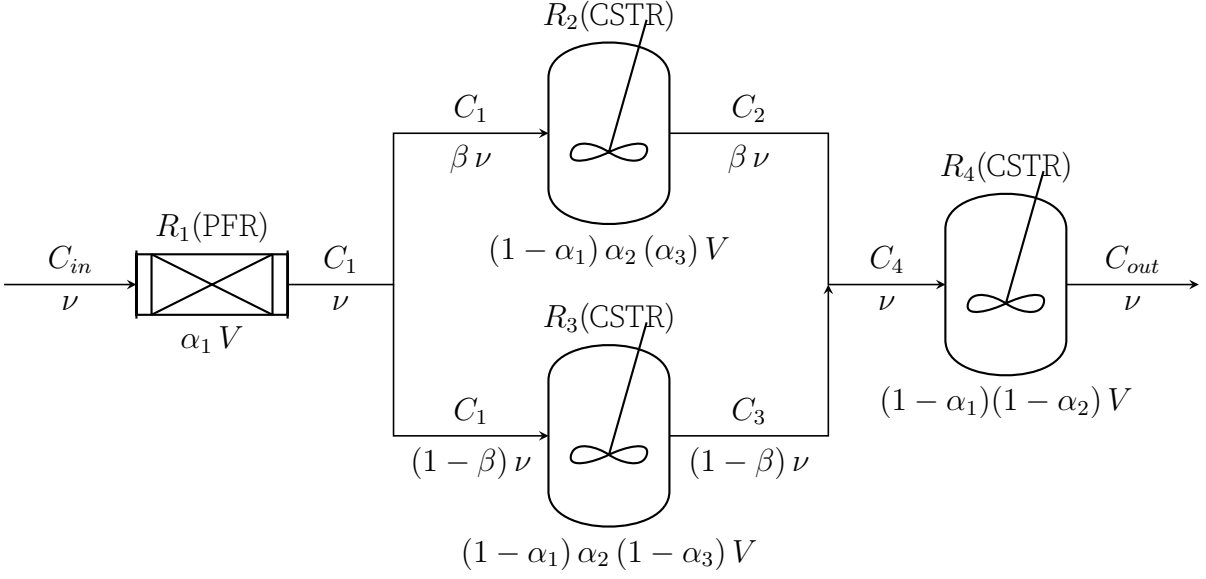
$$\implies C_{3,i+1} = C_{3,i} + \frac{C_1 - C_3}{\tau} \frac{1-\beta}{(1-\alpha_1)(1-\alpha_2)} \Delta t$$

C out

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

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

Modelo 5


R_2(CSTR)
C_1
$\beta\,\nu$
C_2
$\beta\,\nu$
$(1-\alpha_1)\,\alpha_2\,(\alpha_3)\,V$
R_4(CSTR)
C_{in}
ν
R_1(PFR)
$\alpha_1\,V$
C_1
ν
C_4
ν
C_{out}
ν
$(1-\alpha_1)(1-\alpha_2)\,V$
R_3(CSTR)
C_1
$(1-\beta)\,\nu$
C_3
$(1-\beta)\,\nu$
$(1-\alpha_1)\,\alpha_2\,(1-\alpha_3)\,V$

C2

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

$$C_1\,\beta\,\nu = C_2\,\beta\,\nu + (1-\alpha_1)\,\alpha_2\,(\alpha_3)\,V\,\frac{\mathrm{d}C_2}{\mathrm{d}t} \implies$$

$$\implies C_1\,\beta = C_2\,\beta + (1-\alpha_1)\,\alpha_2\,(\alpha_3)\,\tau\,\frac{\mathrm{d}C_2}{\mathrm{d}t} \implies$$

$$\implies \frac{\mathrm{d}C_2}{\mathrm{d}t} = \frac{C_1 - C_2}{\tau}\frac{\beta}{(1-\alpha_1)\,\alpha_2\,(\alpha_3)} \implies$$

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

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

C3

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

$$C_1\,(1-\beta)\,\nu = C_3\,(1-\beta)\,\nu + (1-\alpha_1)\,\alpha_2\,(1-\alpha_3)\,V\,\frac{\mathrm{d}C_3}{\mathrm{d}t} \implies$$

$$\implies C_1\,(1-\beta) = C_3\,(1-\beta) + (1-\alpha_1)\,\alpha_2\,(1-\alpha_3)\,\tau\,\frac{\mathrm{d}C_3}{\mathrm{d}t} \implies$$

$$\implies \frac{\mathrm{d}C_3}{\mathrm{d}t} = \frac{C_1 - C_3}{\tau}\,\frac{1-\beta}{(1-\alpha_1)\,\alpha_2\,(1-\alpha_3)} \implies$$

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

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

C4

$$\boldsymbol{C_4 = C_2\,(\beta) + C_3\,(1-\beta)}$$

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

C out

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

$$C_4\,\nu = C_{out}\,\nu + (1-\alpha_1)(1-\alpha_2)\,V\,\frac{\mathrm{d}C_{out}}{\mathrm{d}t} \implies$$

$$\implies C_4 = C_{out} + (1-\alpha_1)(1-\alpha_2)\,\tau\,\frac{\mathrm{d}C_{out}}{\mathrm{d}t} \implies$$

$$\implies \frac{\mathrm{d}C_{out}}{\mathrm{d}t} = \frac{C_4 - C_{out}}{(1-\alpha_1)(1-\alpha_2)\,\tau} \implies$$

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

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