

*Supporting Information*

# Possible Roles of Amphiphilic Molecules in the Origin of Biological Homochirality

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## 1. Dynamic Equations

### 1.1. General Relationship Among Parameters

In addition to eq S1, S2, and S3, some useful equations to derive dynamic equations are described in this section. These equations describe relationships among parameters  $x_L$ ,  $x_D$ ,  $k_L$ ,  $k_D$ ,  $g$ ,  $\eta$ , and  $\theta$ .

$$\frac{d\eta}{dt} = (-2x_L \frac{dx_D}{dt} + 2x_D \frac{dx_L}{dt})/(x_L + x_D)^2 \quad (\text{S1})$$

$$k_L = \frac{1+g}{1-g} k_D \quad (\text{S2})$$

$$\frac{k_D}{1-g} = \frac{1}{2}(k_L + k_D) \quad (\text{S3})$$

$$x_L x_D = \frac{(x_L + x_D)^2 - (x_L - x_D)^2}{4} = -\frac{1}{4}\theta^2(\eta^2 - 1) \quad (\text{S4})$$

$$x_L^2 + x_D^2 = (x_L - x_D)^2 + 2x_L x_D = \frac{1}{2}\theta^2(\eta^2 + 1) \quad (\text{S5})$$

$$x_L^3 + x_D^3 = (x_L + x_D)(x_L^2 - x_L x_D + x_D^2) = \frac{1}{4}\theta^3(3\eta^2 + 1) \quad (\text{S6})$$

$$x_L^3 - x_D^3 = (x_L - x_D)(x_L^2 + x_L x_D + x_D^2) = \frac{1}{4}\eta\theta^3(\eta^2 + 3) \quad (\text{S7})$$

### 1.2. Reaction Formula and Differential Equations

#### 1.2.1. Block I: Synthesis



$$\frac{dx_L}{dt} = k_L x_A \quad (\text{S10})$$

$$\frac{dx_D}{dt} = k_D x_A \quad (\text{S11})$$

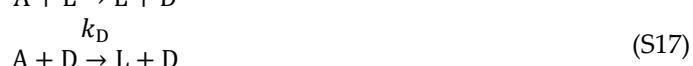
#### 1.2.2. Block II: Racemization



$$\frac{dx_L}{dt} = -k_L x_L + k_D x_D \quad (\text{S14})$$

$$\frac{dx_D}{dt} = -k_D x_D + k_L x_L \quad (\text{S15})$$

#### 1.2.3. Block III: Accidental Autocatalysis



$$\frac{dx_L}{dt} = k_D x_A x_D \quad (\text{S18})$$

$$\frac{dx_D}{dt} = k_L x_A x_L \quad (\text{S19})$$

#### 1.2.4. Block IV: Binary Racemization

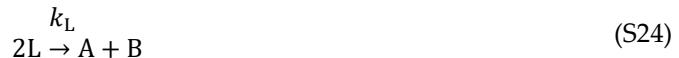




$$\frac{dx_L}{dt} = k_D x_D^2 - k_L x_L^2 \quad (S22)$$

$$\frac{dx_D}{dt} = k_L x_L^2 - k_D x_D^2 \quad (S23)$$

#### 1.2.5. Block V: Binary Racemization



$$\frac{dx_L}{dt} = -2k_L x_L^2 \quad (S26)$$

$$\frac{dx_D}{dt} = -2k_D x_D^2 \quad (S27)$$

#### 1.2.6. Block VI: Accidental Superautocatalysis



$$\frac{dx_L}{dt} = k_D x_A x_D^2 \quad (S30)$$

$$\frac{dx_D}{dt} = k_L x_A x_L^2 \quad (S31)$$

#### 1.2.7. Block VII: Destruction



$$\frac{dx_L}{dt} = -k_L x_L \quad (S34)$$

$$\frac{dx_D}{dt} = -k_D x_D \quad (S35)$$

#### 1.2.8. Block VIII: Autocatalysis



$$\frac{dx_L}{dt} = k_L x_A x_L \quad (S38)$$

$$\frac{dx_D}{dt} = k_D x_A x_D \quad (S39)$$

#### 1.2.9. Block IX: Cross-inversion



$$\frac{dx_L}{dt} = k_L x_D x_L - k_D x_L x_D \quad (S42)$$

$$\frac{dx_D}{dt} = k_D x_L x_D - k_L x_D x_L \quad (S43)$$

#### 1.2.10. Block X: Annihilation



$$\frac{dx_L}{dt} = -k x_L x_D \quad (S45)$$

$$\frac{dx_D}{dt} = -k x_L x_D \quad (S46)$$

#### 1.2.11. Block XI: Superautocatalysis



$$\frac{dx_L}{dt} = k_L x_A x_L^2 \quad (S49)$$

$$\frac{dx_D}{dt} = k_D x_A x_D^2 \quad (S50)$$

#### 1.3. An Example of Deriving Dynamic Equations (Block VI)

As an example, derivation ( $d\eta/dt$ ) of Block VI is described in this section. First,  $dx_L/dt$  and  $dx_D/dt$  in eq S1 are substituted by equations S30 and S31.

$$\frac{d\eta}{dt} = (-2x_L k_L x_A x_L^2 + 2x_D k_D x_A x_D^2)/(x_L + x_D)^2 = -2x_A(k_L x_L^3 - k_D x_D^3)/\theta^2 \quad (S51)$$

By substituting  $k_L$  using eq S2, following equation can be obtained.

$$\frac{d\eta}{dt} = -2x_A \left( \frac{1+g}{1-g} k_D x_L^3 - k_D x_D^3 \right) / \theta = -2x_A \frac{k_D}{1-g} ((1+g)x_L^3 - (1-g)x_D^3) / \theta^2 \quad (S52)$$

By substituting  $k_D/(1-g)$  using eq S3, following equation can be obtained.

$$\frac{d\eta}{dt} = -2x_A \times \frac{1}{2} (k_L + k_D) (x_L^3 - x_D^3 + g(x_L^3 + x_D^3)) / \theta^2 \quad (S53)$$

Using cubic equations S6 and S7, the dynamic equations becomes as follows.

$$\begin{aligned} \frac{d\eta}{dt} &= -x_A (k_L + k_D) \left( \frac{1}{4} \eta \theta^3 (\eta^2 + 3) + g \left( \frac{1}{4} \theta^3 (3\eta^2 + 1) \right) \right) / \theta^2 \\ &= -\frac{1}{4} (k_L + k_D) x_A \theta (g + 3\eta + 3g\eta^2 + \eta^3) \end{aligned} \quad (S54)$$