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Supporting Information

Chemical Patterns in Autoxidations Catalyzed by Redox Dyes

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This file contains more elaborated procedures and results for instructors to use in class.
It contains the following sections:

1. Introduction
2. Chemical composition of the reaction mixture
3. Oxygen concentration above the reaction mixture
4. Physical dimension of the reaction mixture
5. Temperature
6. Time

Other supporting information files are

- 3D printing supporting information (ZIP)
- Additional photographs/animations (ZIP)

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1. INTRODUCTION

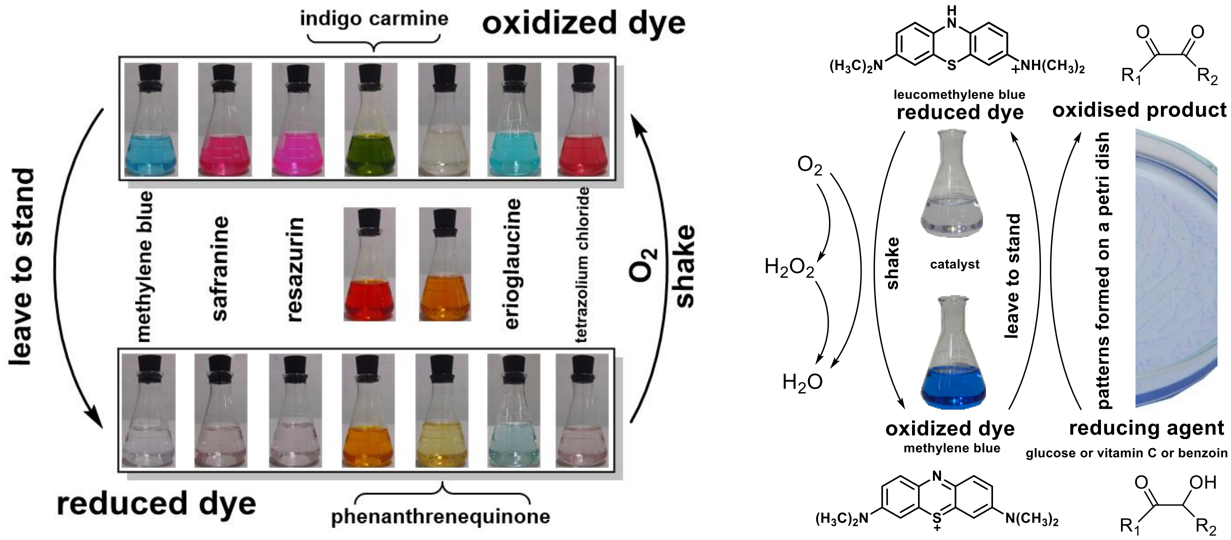

Figure 1S. Left: Different dyes and their colors Right: The reaction scheme of the blue bottle experiment (Adapted with permission from Refs 3,5. Copyright 2016, 2017 American Chemical Society.)

2. CHEMICAL COMPOSITION OF THE REACTION MIXTURE

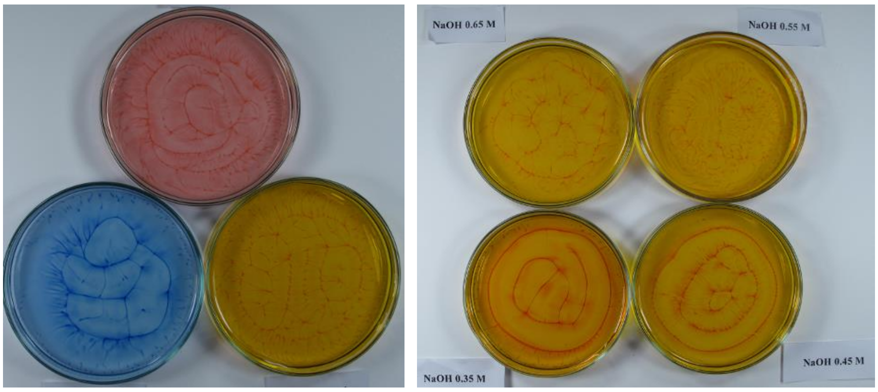

Figure 2S. Left: Patterns formed by three different dyes, safranin, methylene blue and indigo carmine.
Right: Patterns formed by indigo carmine in three different concentration of sodium hydroxide.

2.1 Change the identity of the dye

- Refer to Tables 1 and 2 in the manuscript.

2.2 Change the concentration of a reactant

- Refer to Tables 1 and 2 in the manuscript.

3. OXYGEN CONCENTRATION ABOVE THE REACTION MIXTURE

3.1 Method A: Gas chamber

Two identical transparent jars are used for the reaction. One is closed by a Petri dish as a control and the other has a lid that is fitted with gas inlet/outlet and oxygen probe for elevated or depleted oxygen condition.

3.1.1 Elevated oxygen condition

The oxygen gas is generated by the reaction between hydrogen peroxide and manganese (IV) oxide. (See Refs 6-8.) The gas goes through distilled water before reaching the jar to cool down the gas and remove other water soluble contaminants. The amount of hydrogen peroxide is controlled by a separating funnel as shown in Figure 3S. The oxygen composition in the atmosphere above the solution in this setup may reach as high as 96%.

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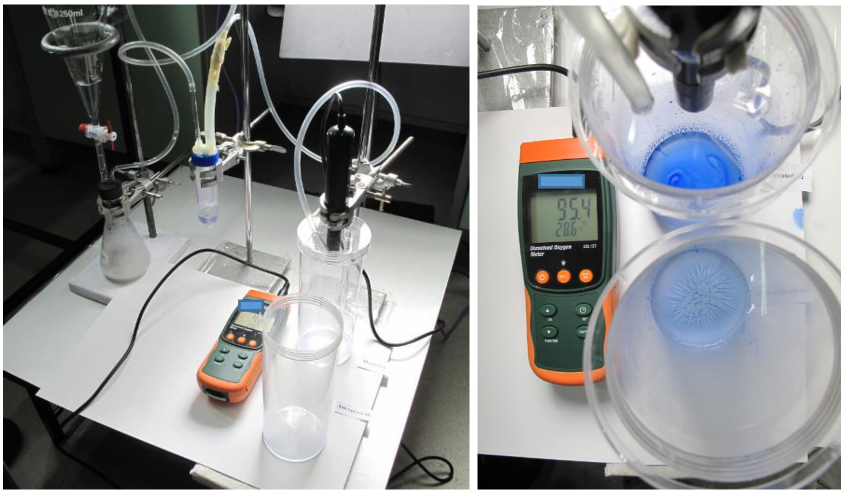

Figure 3S. Left: An experimental setup for oxygen generation.
Right: Patterns have changed under elevated oxygen condition (above) compared to control (below).

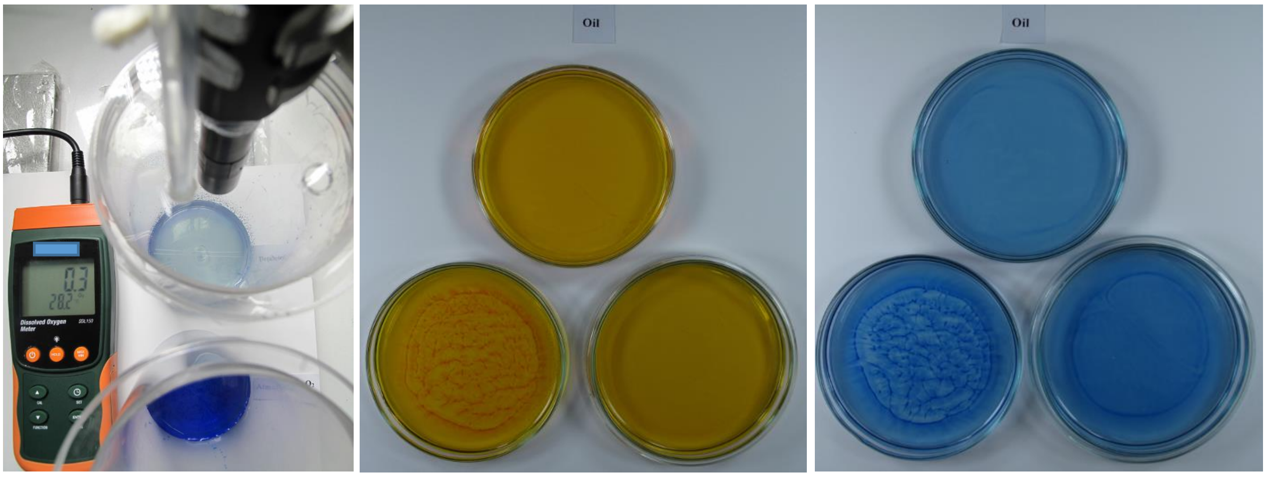

Figure 4S. Left: Patterns do not form under depleted oxygen condition created by nitrogen gas.
Middle/Right: Top: Patterns did not form under depleted oxygen condition created by oil.
Lower left: Patterns formed by indigo carmine/methylene blue in a control group.
Lower right: Patterns partially formed if the dish is covered.

3.1.2 Depleted oxygen

Nitrogen gas from a supply tank is collected in a rubber balloon. Small plastic gas valve and rubber tube are used to connect the rubber balloon to the gas chamber. Balloon is tied to the tube by using a rubber band. The oxygen composition in the atmosphere above the solution in this set up may reach as high as 0.3%.

3.2 Method B: Oil

- One Petri dish should be used as a control.
- Oil can be poured to cover Petri dish to create a depleted oxygen condition. (See Ref 6.)
- Alternatively, the lid of petri dish may be sufficient to disrupt chemical pattern formation. (See the rate of oxygen consumption in Refs 2,5.)

4. PHYSICAL DIMENSION OF THE REACTION MIXTURE

4.1 Method A: Petri dish for solution depth and cross-section area

- According to Figure 5S, reaction mixture can be prepared at once and quickly poured onto different Petri dishes. First photograph can be taken when sodium hydroxide is added to the reaction mixture to record the start time. Experiments for different depths or areas are placed side by side for convenient comparison.

- Both plastic and glass Petri dishes can be used. However, if the amount of the solution is small, the solution will not spread over the whole area of plastic dish due to relatively low adhesive force between plastic and solution. At room temperature, the depth less than 2.0 mm/4.00 mm is not recommended for glass and plastic Petri dish respectively.
- Table 1S lists expected solution depth for various sizes of Petri dish.

Table 1S Typical Petri dish diameter and solution depth in mm.

Volume of solution/ml	Ø=60	Ø=80	Ø=90	Ø=100	Ø=120	Ø=150
10	3.5	2.0	1.6	1.3	0.9	0.6
20	7.1	4.0	3.1	2.5	1.8	1.1
30	10.6	6.0	4.7	3.8	2.7	1.7
40	14.1	8.0	6.3	5.1	3.5	2.3
50	17.7	9.9	7.9	6.4	4.4	2.8

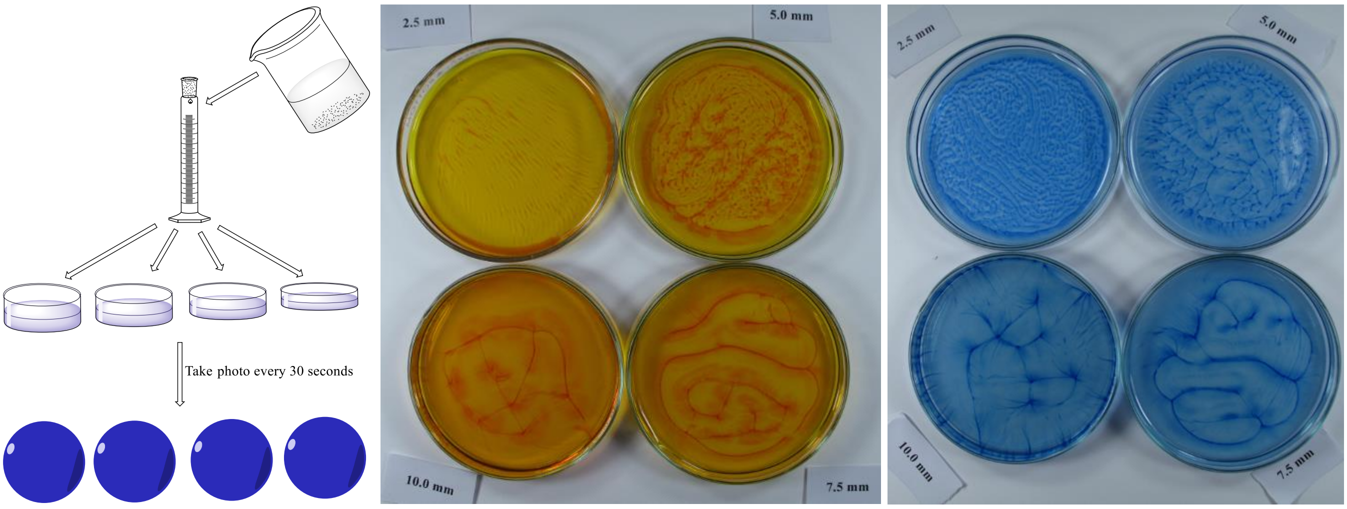

Figure 5S. Left: An experimental procedure to vary the depth of reaction mixture
Middle: Patterns formed by indigo carmine at different depths
Right: Patterns formed by methylene blue at different depths

4.2 Method B: 3D printed trays for different cross-section shape and area

- Chemical preparation and other processes are the same as in 4.1
- Refer to separate files for 3D printing instructions.

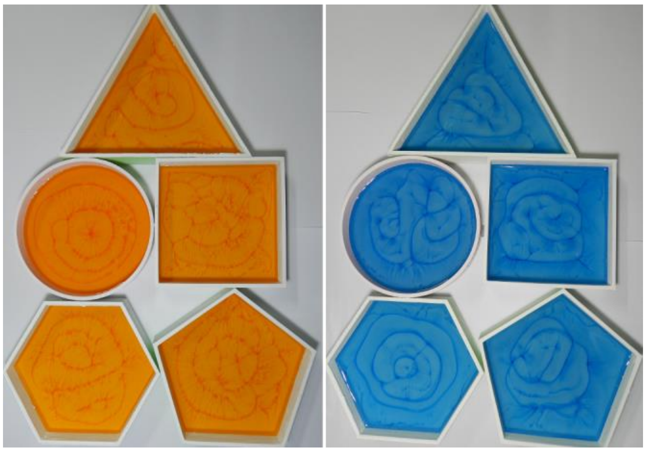

Figure 6S. Left: Patterns by indigo carmine at a cross-sectional area of 100 cm^2 and a depth of 1 cm.
Right: Patterns by methylene blue at a cross-sectional area of 100 cm^2 and a depth of 1 cm.

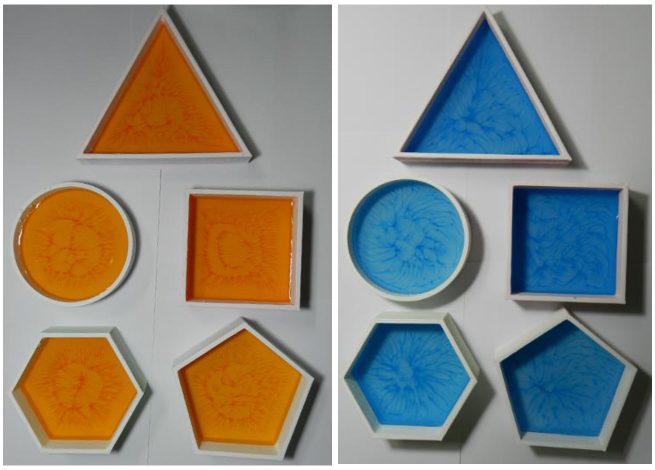

Figure 7S Left: Patterns formed by indigo carmine at a cross-sectional area of 50 cm^2 and a depth of 1 cm.
Right: Patterns formed by methylene blue at a cross-sectional area of 50 cm^2 and a depth of 1 cm.

5. TEMPERATURE

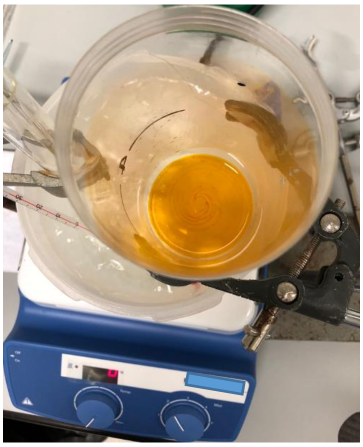

Figure 8S Patterns formed by indigo carmine in hot water.
A magnetic stirrer is used to help maintain the temperature of the jar.
The same jar that is used for 3.1 is used here. Refer to the instruction in the manuscript.

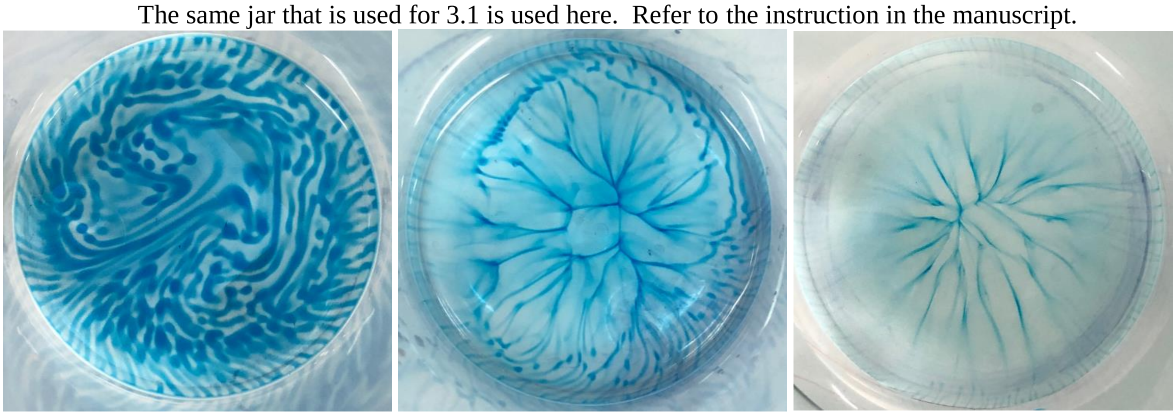

Figure 9S Left: Patterns formed by methylene blue in cold water.
Middle: Patterns formed by methylene blue at room temperature.
Right: Patterns formed by methylene blue in hot water.

6. TIME

See separate files for animations.