INTRODUCTION

My goal is to develop color-based indicators for oxygen concentration. I became familiar with laboratory tools and chemicals used in anoxic (oxygen free) environments. I learned about reduction and oxidation reactions, which represent an important group of chemical transformations in chemistry and biology. Rust formation, spoiled food, and carbon dioxide emission are all based on oxidation reactions; and they are of global importance.

Using oxygen-sensitive chemical compounds that change color upon oxidation and reduction reactions, I developed indicator standards. These can indicate the presence of oxygen and qualitatively estimate its concentration.

The goal was to optimize the oxygen indicators for various sample preparation protocols and for measurements under anoxic conditions.

Potential future applications:

• Anoxic packaging for oxygen sensitive material
• Study of the water-induced oxidation reaction
• Corrosion testing (rust formation due to moisture, humidity and deterioration)
• Dissolved oxygen levels in lakes, ocean, etc.

METHODS

• Study of the water-induced oxidation reaction

RESULTS

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Dilution tests (MV + Na2S2O4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indigo Carmine (IC)</td>
<td>MV 10 min 1</td>
</tr>
<tr>
<td>Methyl Viologen (MV)</td>
<td>MV 1 min &lt;1 min.</td>
</tr>
<tr>
<td>Resorcin (RC)</td>
<td>MV 20 min 2</td>
</tr>
</tbody>
</table>

Testing storage and shipping:

Jar 1: medium jar + teflon tape
Jar 2: medium jar no tape
Jar 3: medium jar + teflon tape, inside small jar + teflon tape
Jar 4: large/medium/small inside small jar + teflon tape

Methylviologen 257 g/moles (Mw / 1000) * 0.3 0.0771 g 77.1 mg
Indigocarmine 466 g/moles or 0.1399 g 139.9 mg
Resorcin 515 g/moles Mw * 0.001 * 0.3 0.1544 g 154.4 mg
Zinc 65.4 g/moles 0.0196 g 19.6 mg

Reactions

1. MV2+ + Zn + H2O + 2 Cl- → MV+ + Zn2+ + 2 Cl+ + H2O
2. 2MV2+ + Na2S2O4 + 2 Cl- → MV+ + 2 H2O + 2 Na2S2O3 + 2 Na+ + 2 Cl-
3. IC + Na2S2O4 + 2 H2O → IC+ + SO32- + 2 Na+ + 2 OH-
4. IC + Zn + H2O → IC+ + Zn2+ + 2 OH-
5. RC + Na2S2O4 + H2O → No Reaction, No Solubility

Recipe for Stock Solutions

We need 100 mM (molarity = 1 mole of compound in 1 dm3 or 1 liter of solution) solution and we have 3 cm3 vials.

- Sodium hydrosulfite
- Zinc

DISCUSSION

- Reduced forms of methylviologen and indigocarmine are sensitive indicators of oxygen content.
- Their aqueous solutions can be readily generated and stored for days without change in color in the glovebox.
- They change their colors (MV: violet → blue) immediately upon exposure to air.
- We used these chemicals to test how well sealed jars can maintain anoxic environment.
- We verified the limited oxygen permeability of tapes and films.

CONCLUSIONS

- Contrary to the general assumption, double jars secured with teflon tape do not provide aerobic and anaerobic conditions.
- For overnight shipping and longer term storage the jars need to be sealed with wax, covered first with electric tape, then with parafilm and, if possible, stored in triple jars.
- Surprisingly, samples between tapes or polypropylene film can be stored for hours in jars.
- Order of resistance (permeability) to oxygen: polypropylene film for 1-2 hr; thin/thick Kapton tape for a day

ACKNOWLEDGMENTS

The research laboratory of RKS is supported by Office of Naval Research, Center for Disruptive Nanomaterials.

This program was supported in part by a grant to Montana State University from theeward Hughes Medical Institute through the Undergraduate Science Education Program.

The MAP program is also supported in part by the Experimental Program to Stimulate Competitive Research (Montana EPSCoR) from the National Science Foundation, and by Designing Our Community (DOC) in the College of Engineering at Montana State University. The MSU College of Education gratefully acknowledges support for the DOC program from The W.W. and Flora Hewlett Foundation.