# Experimenting with LSD and a prism

*Here are novel ways of recombining colours to get white light and making a brilliant, rainbow-coloured arc.*

LSD is new – and not what you may think it is. More of a material than a gadget, the acronym stands for *light shaping diffuser*. If you think of a ground glass diffuser and its effect on light transmitted through it, LSD acts in a related sort of fashion. But more cleverly. It mixes light in the sense of diffusing it, but confines the diffused light within a well-defined beam that can be circular or elliptical in cross section. Depending on its specification, it will shape light into a narrow or broad beam either with no divergence or lots of divergence. As a result it is a superb tool for optical engineering.

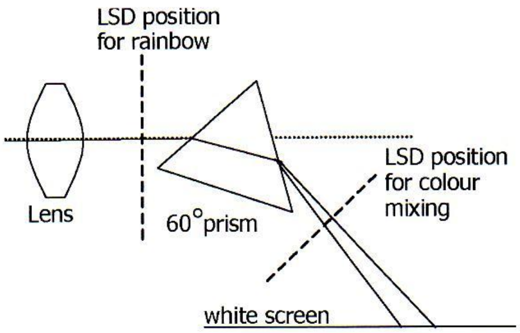


**Figure 1** *Positions of LSD with respect to the prism and other optical elements to get the effects shown in Figures 2-5.*

For instance, suppose you were to use a prism to disperse white light into a spectrum from red to violet (Fig. 1). Then place the LSD in the dispersed beam creating zero divergence across the spectrum but lots of divergence perpendicular to it. This spreads out the spectrum vertically into a vertical spectral ribbon (Fig. 2). Now rotate the LSD, causing the spectrum to rotate to an oblique line. The more it turns, the more the colours mix producing white in its middle with outer fringes of red and violet (Fig. 3). After being turned through 90 degrees all of the colours become completely mixed and you see a horizontal band of white (Fig. 4). It is therefore a very nifty improvement on Newton's famous experiment where he split white light into a spectrum with one prism and recombined the colours with, some-times, a second prism, and, other times, a lens, to create white light again.

If the LSD is then placed in front of the prism such that the white light entering the prism has been shaped to be a diverging vertical ribbon, the light undergoes two rotations: (1) about a horizontal axis on passing through the LSD; and (2) about a vertical axis on passing through the prism. The outcome is an arc like a rainbow - the most brilliantly vivid rainbow I have ever seen generated artificially (Fig. 5).

In physical form, LSD is a plastic sheet one surface of which has the topography of computer-generated lumps and humps shaped to control the directions in which light is diffused - hence its name (Light Shaping Diffuser). It's not cheap, but SSERC has bought in some sheets of the stuff and cut it down to size for fitment within a 35 mm slide holder for convenient use by schools. We are selling these small bits at £4 a piece, roughly the same price as a low-cost ground glass diffuser. We think that it's a bargain. LSD is the sort of stuff that up until now you will never have wanted because nothing like it ever existed, but once you start playing with it, you realize how useful it is and it becomes indispensable. We can supply you with two types of LSD (Table 1).

| Light-shaping nature of LSD | Spec. | Function | Suggested uses |
|---|---|---|---|
| Elliptical cross-section beam | 40° x 0.5° | Generates a narrow wedge of diffuse light radiating from the LSD through an arc of 80° | Mixing a spectrum to produce white light. Artificial rainbow. |
| Round cross-section beam | 10° | Generates a 20° cone of diffuse radiation diverging from the LSD | Directional diffuser. Cleans up LED radiation for colour mixing and other experiments. |

**Table 1** *Types of LSD stocked by SSERC. Supplied in 35 mm slide holder at £4 a piece.*

**Figure 2** *Ribbon spectrum created with 40° x 0.5° LSD set up in the refracted radiation. The LSD's plane is vertical and orthogonal to the radiation.*

**Figure 3** *Rotation of LSD in a vertical plane about a horizontal axis causes the spectrum to turn, mixing the colours. The central part has become white.*

**Figure 4** *Further rotation of the LSD results in all of the spectral colours mixing, producing white.*

The artificial bow is the result of placing the LSD in the white light before it enters the prism. The upper part of the arc has lost its circularity because it has been cast on a plane screen.

***Figure 5*** *The artificial bow*

Other rainbows can be made by placing LSD after the prism and turning the plane of the LSD to an oblique orientation with respect to the optical radiation. It is possible to make a bow that circles back down to the horizon.

# An Oscillating Reaction

## Introduction

This oscillating reaction is known as the Briggs-Rauscher (BR) reaction.

The mechanism is very complex and involves iodide ions and iodine molecules. The species HOI is formed in one reaction and consumed in another. As its concentration rises and falls, it triggers oscillations in the $I^-$ and $I_2$ concentrations. It is thought that the colourless solution arises when $I_2$ is low and $I^-$ is high; it is yellow when $I_2$ is high and $I^-$ is low; and blue when $I_2$ and $I^-$ concentrations are both high (when both are high they form pentaiodide ions which gives rise to the blue complex with starch).

The reaction can be used in S2 to show changes in appearance due to chemical reactions (5-14 Guidelines, Science, Target ES-F3.2, Changing Materials, Level E; in Standard Grade, Intermediate 1 and 2 to show chemical reactions and in Higher to show a reversible reaction. It also makes an eye-catching demonstration for an open evening/parents' night and has the advantage of not depending on expensive transition metal catalysts for it to work. The oscillations can last for about 5 minutes.

## What you will need

### Chemicals

hydrogen peroxide solution, 100 vol.
manganese(II) sulphate mono-hydrate
sulphuric acid, 0.1M
potassium iodate
malonic acid
starch, soluble
distilled water

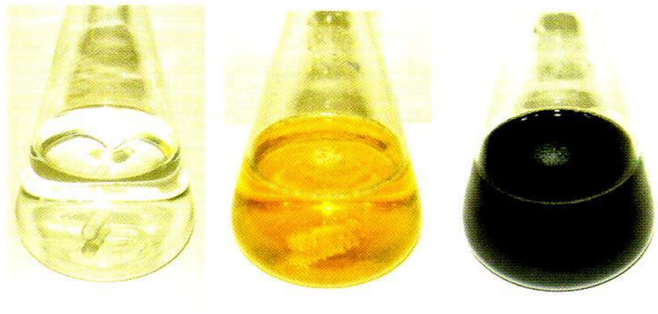

***Figure 1*** *Oscillating reaction shown at the start and the two colours evident when the reaction starts to oscillate.*

### Equipment

conical flasks, 4 x 250 ml
measuring cylinders, 3 x 50 $cm^3$
stirring rod or magnetic stirrer with follower
balance (0.1 g resolution)

## Preparation of solutions

Forget the complex recipes you may have seen elsewhere and follow this simplified one which we know works well. Always use distilled water as the chloride ions in tap water can interfere with the reaction.

**Solution 1** - Weigh out 4.3 g of potassium iodate (OXIDISING, IRRITANT, HARMFUL) and dissolve in 100 $cm^3$ of 0.1M sulphuric acid (IRRITANT) in one of the conical flasks.

**Solution 2** - Prepare 100 $cm^3$ of a 0.1% solution of soluble starch.

Weigh out 1.5 g malonic acid (OXIDISING, IRRITANT, HARMFUL) and 0.4 g magnesium sulphate and dissolve these in the cold starch solution.

**Solution 3** - Prepare a solution of hydrogen peroxide by diluting 30 $cm^3$ of 100 volume hydrogen peroxide (CORROSIVE) to a total volume of 100 $cm^3$ with distilled water.

## The demonstration

Measure out 50 $cm^3$ of each solution (1 to 3) in three separate measuring cylinders. Add them to a 250 $cm^3$ conical flask and stir with a stirring rod or magnetic stirrer. Once the solutions are mixed thoroughly, ask the students/observers to describe and record what happens and when.

**Note** - The preparation of the solutions and reaction should be done in a well-ventilated lab.

After the reactions have oscillated back and forth the solution remains as a blue-black mixture with the smell of iodine. Occasionally some purple fumes of iodine can be seen (HARMFUL & DANGEROUS FOR THE ENVIRONMENT). Care should therefore be taken if the demonstration is scaled up.

It is also possible to scale the reaction down. We have successfully used 30 $cm^3$ "disposable" universal plastic containers for 5 $cm^3$ portions of each of the three solutions. This allows the reaction to be carried out by individual students. Make sure the universal container has a screw cap to avoid spillage. Once shaken, the container can be placed on the bench and the oscillations studied dfor up to 5 minutes.