# Journal of Interdisciplinary Science Topics

## Is purple rain possible?

Saffron Foster
*Natural Science, University of Leicester*
16/04/2018

**Abstract**
*Purple Rain*, as sung by Prince could be possible in reality. Throughout history, 'blood rains' have been seen where rain appears red. The knowledge of this phenomenon allows a method to be devised in order to obtain purple coloured rain. The suspension of a potassium permanganate powder within the atmosphere seems to be the most practical and safe way to produce this 'purple rain' effect.

**Background**
Purple rain, a song released in 1984, is one of the most notable by artist, Prince [1]. The lyrics are thought to be about having faith through difficult times with loved ones. For this paper however, it is to be considered in the literal sense and the viability of 'purple rain' will be discussed.

Rain is usually transparent and occurs from the condensation of water vapour in the atmosphere. This condensation occurs from clouds becoming increasingly dense, until precipitate forms. Hence, water vapour in the atmosphere at 25 $^{o}$C can precipitate at 0.00317 MPa [2].

**Discussion**
In order to achieve this effect, a substance which is purple can be dissolved in a solvent. Due to the difficulty of achieving clouds of a single chemical to condense into the 'purple rain'.

**Method 1: Boiling points**
One method to consider in the creation of purple rain is through boiling points. However, within the atmosphere it is the change in pressure which causes condensation rather than falling temperature. If boiling points were considered alone, clouds of chemicals of similar boiling points could be used. In this theory, it is not pressure which causes precipitation, but rather temperature. Hence, when they condense, the purple chemical would dissolve in the solvent.

For example, purple iodine clouds have a boiling point of 185 $^{o}$C, meaning an organic solvent with a higher boiling point would be required for the iodine to dissolve. Hence, the solvent would condense first, then the iodine gas, so it could immediately dissolve. A suitable solvent could be dimethyl sulfoxide, which has the boiling point of 189 $^{o}$C [3].

Nonetheless, this is unrealistic, impractical and hazardous. This large increase in atmospheric temperature is not energy efficient and would be detrimental to most organisms. Dimethyl sulfoxide would also cause harm to organisms if inhaled or in contact with the skin [4].

**Method 2: Natural phenomena**
Methods considering the boiling points and pressure are inaccurate and difficult to prove practically. Therefore, current natural phenomenon can be investigated. 'Blood rain', is a reoccurring unusual event displaying coloured rain. They are thought to be caused by red dust particles within the air. These red dust particles were theorized to be the result of meteor air bursts or spores from microorganisms [5]. A microorganism which is known to contribute to red rain is *Trentepohlia annulata*, which disperses spores which are red and can dissolve in rain [6]. As this is a real-life example of how coloured rain would be produced, a purple powder dispersed in the air may be the best way to produce purple rain.

A common chemical known to turn water purple, in high enough concentrations, is potassium permanganate [7]. The chemical is used in water as

a disinfectant in drinking water as it oxidises iron and manganese, so it is not harmful for humans at suitable concentrations and is even used for medical purposes [8]. Although at higher concentrations potassium permanganate is more likely to cause irritation to the skin [9]. In water, potassium permanganate reacts slowly in the reaction shown in Equation 1. This reaction does not have the permanganate ions present to create a purple solution, but without the presence of a catalyst, an increase in temperature or this long time period, it is assumed that equation 1 will not occur [10]. Equation 2, where the potassium permanganate simply dissociates in the solution, is the process which will occur in order to create the purple rain.

The equation below shows the slow reaction between potassium permanganate and water [9]. This reaction is unlikely to occur without the presence of heat or a catalyst in the timeframe which is considered for purple rain:

$$4KMnO_4 + 2H_2O \rightarrow 4MnO_2 + 3O_2 + 4KOH$$

The equation below shows the dissociation of potassium permanganate into potassium and manganate ions in water. This occurs instantaneously when the powder is added to the water:

$$KMnO_4 + H_2O \rightarrow K^+ + MnO_4^- + H_2O$$

In order to get the desired colour, around a 1:10,000 dilution would be required [11]. This is the same dilution used for the treatment of eczema, hence at this dilution, the hazardous properties of potassium permanganate will not occur [8]. Therefore if the powder is fully dissolved and exposure is not too prolonged, the suspension of fine potassium permanganate powder within the troposphere is the most plausible method [9]. In order to reduce these hazards, the higher the powder is suspended, the less likely the powder will come into contact with the skin of organisms to cause irritation [9]. The troposphere is where most weather occurs, most clouds condense, hence, the powder can be dissolved when precipitation occurs [12].

Practically, it would be difficult to ensure the correct dilution and hence colour. If the dilution is lower than 1:10,000, pink rain will likely fall, if higher than 1:10,000, black rain would occur [12]. In order for this experiment to be successful, an area of low wind may be best. This would ensure the powder does not blow or spread out of the designated area.

If the purple rain falls into bodies of water, where organisms which have a lower toxicity threshold than 100 $\mu g\ L^{-1}$ for potassium permanganate are, issues could arise. There are a small number of aquatic organisms which are below this threshold, including *Branchiura sowerbyi*, *Ictalurus punctatus*, *Daphnia magna*, but the majority are not [13]. A larger concern is whether the water evaporates, leaving solely the potassium permanganate powder, as it is the powder itself which is hazardous. As it is not only an irritant, but can cause lung oedema if ingested and even enhances the combustibility of other substances [9].

**Conclusion**

After multiple methods were considered, the real-life example of 'blood rain' was chosen as the most plausible method to produce purple rain. To mimic the creation of blood rain, suspended potassium permanganate particles in the air can be dissolved. This approach will also be the least hazardous, as the powder irritating properties can be minimized by reducing the contact of the powder itself with the environment, such as increasing altitude for the dispersion of the powder and choosing an area with continuous rainfall and little wind.

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