TECHNICAL BULLETIN

SUBJECT	The Colour of Petroleum-Based Liquids
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Introduction

Historically, the physical property of colour has been used as a method to identify various petroleum-based liquids. This assisted those in the petroleum industry, particularly those handling petroleum liquids in the supply and distribution process, who needed a quick and simple way to verify the identity of a liquid as it moved through the supply chain. When investigating the cause of a fire, various petroleum-based liquids may be found at the scene, and preliminary identification of these liquids may assist the scene examiner in their inquiries. While laboratory analysis of any questioned liquid is always required, this Technical Bulletin describes how colour can be used to narrow down the identity or potential use of an unknown liquid before confirmatory chemical analysis results are received, potentially providing useful data for use in questioning witnesses and evaluating hypotheses.

Petrol

As petrol is the most common liquid accelerant, and due to its ubiquity in homes and businesses, a discussion regarding the changes in the colour of petrol over the years is pertinent.

The colour of petrol sold in Australia has undergone various changes over the last decade. Prior to 2015, unleaded petrol was dyed with two different colours. This made it possible to distinguish between lower octane (i.e., 91 RON, 95 RON) and premium (98 RON) petrol grades. Lower octane petrol was dyed purple, while premium petrol was dyed yellow. In decades prior, premium leaded fuel was dyed red until such fuels were phased out. Lead replacement fuels were also dyed red until they were withdrawn from the market in 2006.

Multiple colours are sometimes used to describe some petrol grades (i.e., purple/bronze) because the natural colour of undyed petrol can vary from colourless to yellow. This is dictated by the original crude oil feedstock and the colour of other refinery blends used to formulate the petrol batch. There are no specific chemical compositional requirements for petrol other than restrictions on the amounts of some minor components, therefore its composition and colour can vary between

refineries and over time. Addition of dye to a more intensely coloured base fuel will alter the final colour. For example, addition of purple dye to a colourless petrol will result in a vibrant purple liquid. However, if the base petrol is already yellow, addition of purple dye will result in a bronze colour.

Starting in October 2012, members of the Australian Institute of Petroleum acted to change the colour of lower octane petrol grades to red, which up until this point had been dyed purple. This transition was completed by the end of 2013, although petrol stocks with old and new colours were sold throughout this transition period. The colour of premium unleaded petrol remained unchanged from yellow. This change brought the Australian petroleum industry in line with most of its Asian Pacific suppliers. Addition of red dye to low octane petrol meant that the final product would either be red or orange in colour.

Figure 1: Colour of various unleaded petrol grades sold in Australia during 2012-2013. Left: premium unleaded petrol (yellow). Centre: 91 RON unleaded petrol up until October 2012 (purple). Right: 91 RON unleaded petrol after October 2012 (red). Source: AIP.

Commencing in October 2015, a decision was made to remove dye from lower octane unleaded petrol grades (including E10) altogether. These grades of petrol, which had been dyed red since 2012, would exhibit either no colour at all, or a slight yellow hue. In the 12 months from October 2015 to 2016, both dyed and undyed unleaded petrol were sold throughout Australia until the supply of dyed petrol was consumed. These changes aligned with changing practices in international markets including the USA, Asia, and Europe. With the removal of dyes from lower octane petrol grades, there was no longer any way to visually differentiate between low octane (colourless or yellow) and premium fuels (yellow). Premium fuels continued to be dyed yellow.

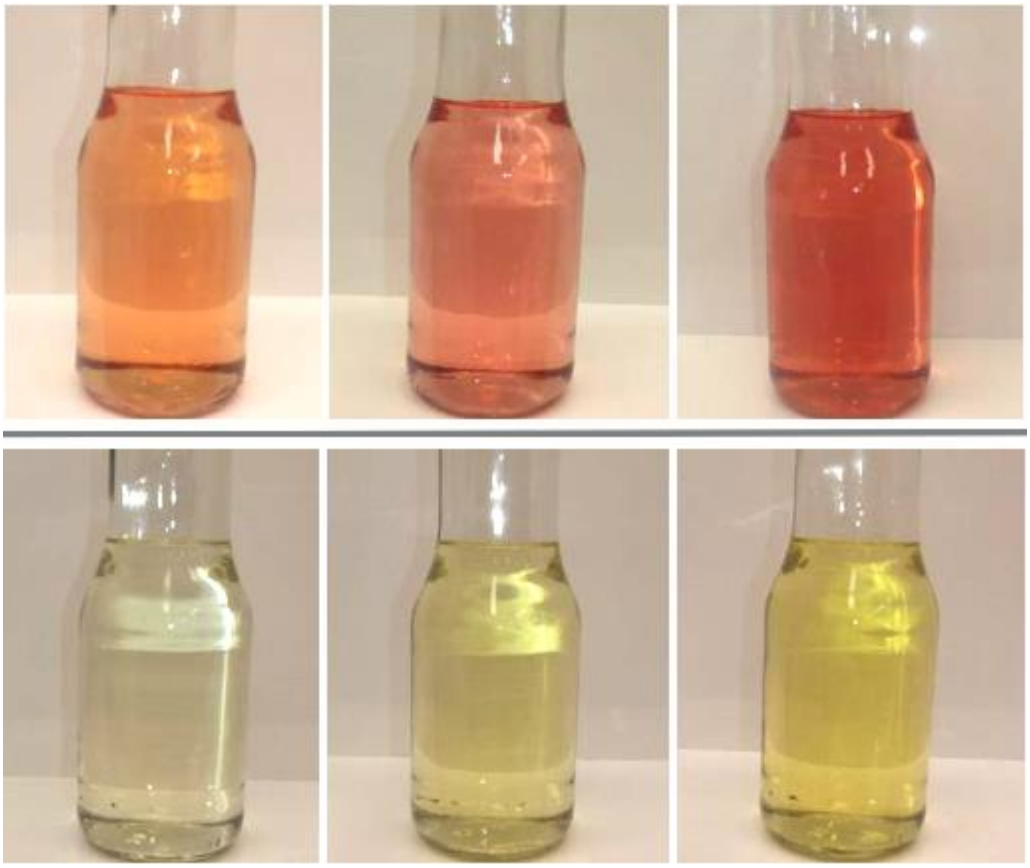

Figure 2: Changes to the colour of unleaded petrol during 2015. Top: unleaded petrol (dyed red/orange) up until October 2015. Bottom: unleaded petrol (colourless/yellow) after October 2015. Source: AIP.

More recently, Australian Institute of Petroleum members have made another change to the colour of petrol products sold in Australia. As of August 2021, unleaded petrol will no longer by dyed with any colour, regardless of the grade. Up until this point, premium unleaded fuels were still dyed yellow, but were difficult to differentiate from undyed petrol grades. Continued dying of premium petrol was deemed unnecessary as monitoring equipment and procedures no longer needed to rely on colour to assist in differentiating between petrol grades. The most recent changes bring Australia into conformity with other international markets, which do not dye petrol. The colour range for all unleaded petrol in Australia is now described as "*Colourless"* (also referred to as Water White) through to *"Yellow*".

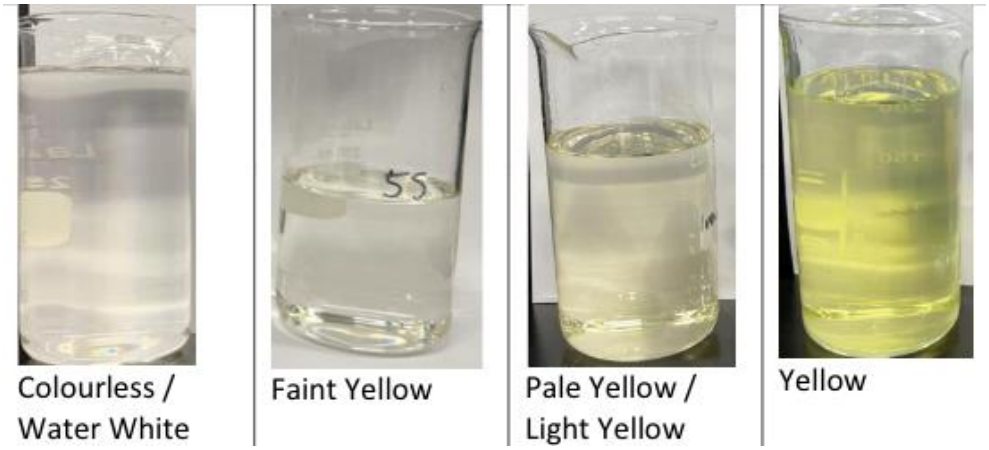

Figure 3: Depiction of the new colour range of all grades of unleaded petrol from August 2021. Source: AIP.

Low aromatic fuels are the exception to the above and continue to be dyed a yellow colour. Low aromatic fuels are unleaded petrol grades which have undergone treatment to reduce the number of aromatic compounds present. Aromatic compounds are a significant component of regular unleaded petrol and are responsible for the characteristic odour. Low aromatic fuels do not emit this characteristic odour. They were designed to reduce the abuse of petrol as an inhalant (petrol sniffing). Low aromatic fuels are not commonly available and are primarily sold in remote regions of the country, particularly in the Northern Territory. A map of areas where low aromatic fuels are sold is available from the National Indigenous Australians Agency.

Other petroleum-based liquids

If you visit a store where ignitable liquids are sold, you may observe that some ignitable liquids tend to be dyed a specific colour. This are several reasons for this.

Some liquids may be dyed differently depending on how they are taxed. Ethanol, for example, is taxed heavily when used in alcoholic beverages, but is sold concessionally for other uses. Some jurisdictions dictate that batches of such liquids are dyed depending on their intended end use, such that fraud can be more easily detected when concessionally taxed liquids are misused.

As liquids with similar packaging may be sold alongside one another, colour differentiation prevents use of the wrong liquid for a specific task. As an example, priming fluids and liquid cement products are commonly used for joining PVC pipes. They typically use methyl ethyl ketone (MEK) as the solvent; therefore, they cannot be differentiated by smell. These products often appear on the same shelves in hardware stores and can be packaged in the same type of bottle. Colour coding allows for easier product selection.

Some liquids are a certain colour due to their production. Changes in manufacturing practices have allowed manufacturers to produce liquids using new technologies, which may impart a specific colour on the product. Alternatively, cleaner and more efficient manufacturing processes may produce a colourless liquid, whereas traditional production methods may only be able to produce coloured liquids due to the presence of impurities.

The table below lists several ignitable liquids which are typically dyed a certain colour. The combination of colour and location within a fire scene may be indicative of their potential use. However, a sample of liquid should always be collected for confirmatory laboratory analysis.

Table 1: Typical colours of some ignitable liquid products.

Liquid	Typical colour		
Kerosene	Blue		
Citronella-scented lamp oil	Bronze	Orange	Light brown
PVC priming fluid	Red		
PVC solvent cement (Type N)	Blue		
PVC solvent cement (Type P)	Green		
Citrus solvent-based cleaners and degreasers	Yellow	Orange	

Vehicle fluids

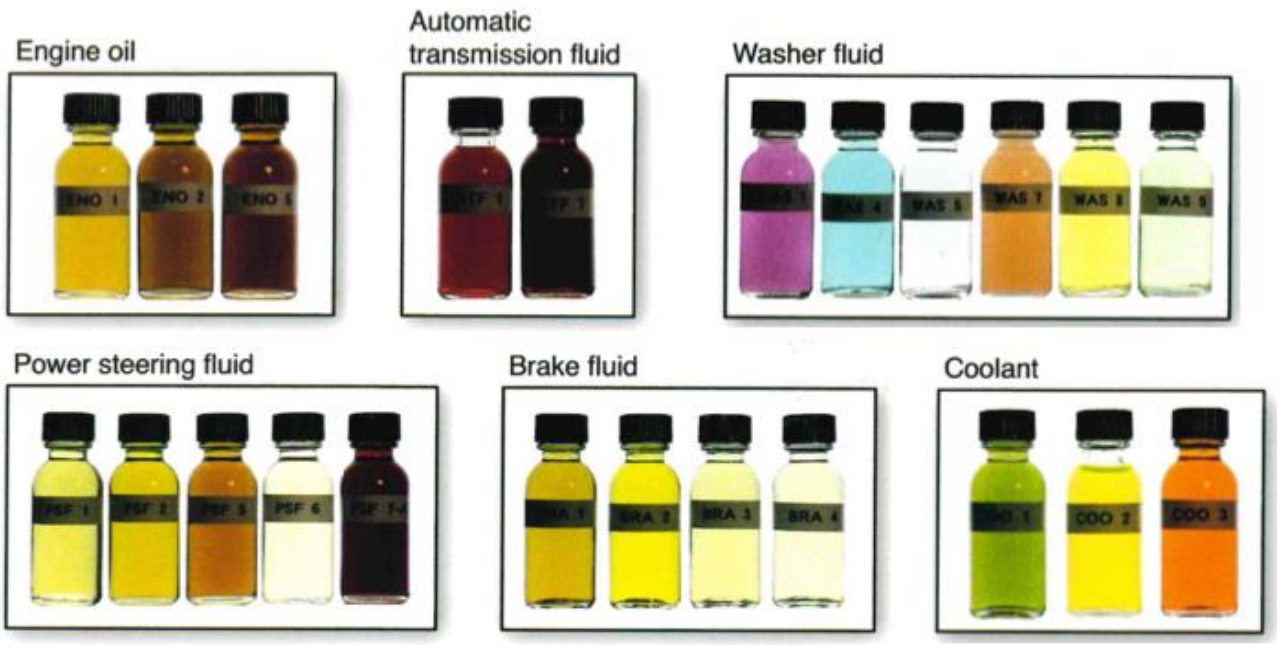

Figure 4: Depiction of various vehicle fluids and their colours. Source: Stauffer et al.

When examining the cause of a vehicle fire, it is often necessary to establish whether a hydraulic or fuel system liquid was involved. Vehicle fluids are generally dyed for the purpose of quick and easy identification when performing servicing and repairs. In some cases, the colour of the liquid can assist in determining whether an incorrect fluid was used for a specific application. Of course, laboratory confirmation of the type of liquid is always required should this data be used as the basis for any forensic opinion.

Note that vehicle fluids will darken as they age due to accumulation of contaminants in the fluid. For example, automatic transmission fluid may be red when fresh, but almost black in a vehicle where it has never been changed.

*Figure 5: Depiction of the colours of various **used** vehicle fluids. From L-R: engine oil, gear lubricant, power steering fluid, automatic transmission fluid, brake fluid, coolant. Source: Stauffer et al.*

Vehicle fluid colours are also not standardised, and two different fluids may exhibit an entirely different colour yet function identically. Confusingly, some vehicle fluids are also interchangeable. For example, power steering fluids are often used interchangeably with automatic transmission fluids. Light-duty gearboxes may use automatic transmission fluid instead of a specialised gear oil.

Therefore, an unexpected fluid colour may not necessarily indicate the wrong fluid has been used; an appropriate fluid may have simply been substituted instead.

A list of vehicle fluids appears below with colours generally associated with these liquids. “Hydraulic fluid” generally refers to fluid used in heavier equipment and mobile plant. While some of the other liquids in this list are certainly hydraulic fluids, they are not all designed for use in extremely high pressure or high torque applications. When examining items of heavy equipment, detailed records should be sought of the fluids used in each vehicle system, and samples of each system fluid should be retained.

Table 2: Typical colours of fresh vehicle fluids.

Vehicle fluid	Typical colour (when fresh)					
Diesel fuel	Light brown	Straw	Colourless	Yellow	Light green	
Engine oil	Golden brown	Bronze	Dark brown			
Automatic transmission fluid	Red	Dark red				
Power steering fluid	Colourless	Yellow	Brown	Dark brown		
Brake fluid	Colourless	Yellow	Light brown			
Gear lubricant	Brown					
Coolant	Green	Yellow	Red	Orange	Blue	Pink
Washer fluid	Colourless	Yellow	Orange	Blue	Pink	
Hydraulic fluids	Brown					

Petroleum liquid containers

While the colour of the liquid itself is the most pertinent identifying factor, the colour of the container the liquid is stored in may also be of interest to the fire examiner. In Australia, most commercial fuel containers are colour-coded as listed in the table below. However, as the liquid within the container may not be consistent with the colour of the container, confirmation of the type of liquid present must always be sought from a laboratory.

Table 3: Typical colours of ignitable liquid storage containers.

Product	Container colour
Petrol	Red
Diesel	Yellow
Kerosene	Blue
Two-stroke fuel	Green
Water	Light blue
Non-designated	Black

Conclusion

Liquids including basic petroleum-based liquids and vehicle fluids may be dyed a specific colour. While liquid colour is not a confirmatory identification method, it may allow a fire examiner to narrow

down the liquid's origin or intended use. This may provide additional data to the examiner during scene examination and before the results of any laboratory chemical analysis are known. Examiners are reminded that samples of any forensically significant liquid must always be submitted to the laboratory for examination should their identity become evidentially significant.

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