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**Short communication**

# Solar thermal fluids – why it is so important to choose the right fluid

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A B S T R A C T

In 2011 the global heat transfer (HTF) market was estimated to be worth $1,684 and is projected to be worth $2,557 million by 2017. The generation of energy from the solar sector is one area that is growing with a projected output of 630 GW by 2050. In the concentrated closer power (CSP) sector, the most commonly used HTF is the eutectic mixture of biphenyl diphenyl oxide (BDO). The chemistry of this fluid means that CSP plants can operate up to 400 degrees Celsius. However, this is not the only key feature of a HTF as other parameters need to be considered. This article discusses the key features of a BDO fluid.



## 1. Introduction

The sole purpose of a HTF is the sole purpose of a HTF is to transmit heat from one location to another. In manufacturing and production processes, a number of HTFs are used. The main types are air or other gases; water or steam; mineral based HTFs; synthetic based HTFs (i.e., BDO fluids); molten salts; and, liquid metals[1]. BDO HTFs are commonly used as a heat carrier in CSP plants. A recent article entitled ‘Comparing the thermal stability and oxidative state of mineral and biphenyl diphenyl oxide based heat transfer fluids’ (Wright, 2016) sought to explain why this type of fluid was so commonly used. To answer this, the research focused on two key aspects:

1. The physicochemical properties of a HTF.
2. The thermal stability of a HTF gained form real-world data.

In order to explain why these are so important, BDO fluid was compared with mineral-based HTF to highlight potential differences between these fluids. This is discussed in further details below.

**2. Physicochemical properties**

Table 1 was extracted from the publication in the Journal of Applied Mechanical Engineering (Wright, 2016) and compares the typical physicochemical properties of a mineral and BDO-based HTF. The notable difference is the operating range and more specifically the upper operating temperature. Indeed, the BDO-based HTFs has a maximum operating temperature that is 120°C higher than the typical mineral-based HTFs. Leading the author to state that:

> "The upper operating temperature of the BDO-based HTF is 400°C and is a reflection of the fluid's superior thermal stability as compared with a mineral-based HTF."

The second key difference is the kinematic viscosity of these fluids with the BDO fluids having a lower viscosity than the mineral-based HTFs and it also only changes slightly between the lower and upper operating temperatures (4.5 and 0.97 $mm^2/s$ at 40 and $100^0C$ respectively). This means that the BDO fluid has better pumpability than the mineral-based HTF.

The third key property to highlight is the boiling point with the mineral HTF having a boiling point above its upper operating temperature, where the BDO fluid has a boiling point below its upper operating temperature. Vapour heating offers some key advantages compared with a mineral fluid including more heat per unit mass of heat medium; a more uniform heat source and better control of temperature; and, it offers better control of flow in systems where it is difficult to control liquid flow pattern andvelocity (Dowtherm A Heat Transfer Fluid, 2016).

The systems used also have some key advantages as vapour heating system require no pumps when agravity return condensate system isused in conjunction with a natural circulation vaporiser; they have fewer working parts; and, heating is potentially more economical when using condensing vapour as compared with a liquid at high mass flow rates (Dowtherm A Heat Transfer Fluid, 2016).

**Tabel 1**
Typical physicochemical properties for commercially available mineral and BDO-based HTFs.

| **Parameter** | **Unit** | **Mineral-based HTF** | **BDO-based HTF** |
|---|---|---|---|
| Other HTF examples | Descriptive | BP Transcal N, Globaltherm M, Shell Thermia B | Dowtherm A, Globaltherm Omnitech, Therminol VP-1 |
| Operating range | $^0C$ | -10 to 320 | 15 to 400 |
| Appearance | Descriptive | Viscous clear-yellow liquid with a mild odor | Clear-to-light yellow liquid with a geranium-like odor |
| Density at $25^0C$ | $kg/m^3$ | 873 | 1056 |
| Kinematic viscosity (at 40, $100^0C$) | $mm^2/s$ | 29.8, 4.5 | 2.5, 0.97 |
| Auto-ignition | $^0C$ | >320 | 621 |
| Maximum film | $^0C$ | 330 | 425 |
| Boiling point at 1013 mbar | $^0C$ | 365 | 257 |
| Open flash point | $^0C$ | 230 | 123 |
| Closed flash point | $^0C$ | 210 | 113 |

**3. Thermal stability**

The superior thermal stability of the BDO fluid was also recently a topic of discussion at a webinar hosted by Process Heating and entitled 'What to consider when making the buying decision about a heat transfer fluid for your system' (Hosted by Heat Processing on 2nd December, 2015). In this webinar there was a presentation by Ryan Ritz, the Global Business Development Manager at Paratherm Heat Transfer Fluids, stating that the key product features of a well-designed high temperature HTF included its thermal stability, its purity and its heat transfer efficiency. Of course, the HTFs with the best key features will attract a higher price and this would explain why synthetic HTFs are more expensive than mineral-based HTFs.

However, this explains the choice of a fluid from a buyer's perspective, but it does not give actual insight into actual performance of the fluid in the real-world. This is what was presented in the research article 'Comparing the thermal stability and oxidative state of mineral and biphenyl diphenyl oxide based heat transfer fluids' (Wright, 2016). Thermal stability based on real-world data was assessed from comparisons of carbon deposits against closed flash point temperature. These parameters were chosen because as a fluid thermally degrades a fluid is broken-down into short and long chain hydrocarbons. The accumulation of longer chained hydrocarbons is detected as a rise in carbon deposits in the fluid whereas the accumulation of shorter chains can be detected by a decreasing closed flash point temperature. The results showed that mineral-based HTFs had a wider range of carbon deposits in the HTF with more results obtained at the highest levels carbon residue ($\geq 1$ % of the HTFs weight). In comparisons, the BDO HTF had carbon values that were lower on average. Thus demonstrating the need to assess carbon residue closely for mineral-based HTFs. Interestingly, in the samples tested, the closed flash points were relatively stable and there were no real declines for either fluid.

## 4. Conclusion

The most popular fluid used in CSP plants is the eutectic mixture of BDO. This fluid has a high operating temperature (up to 400 degrees Celsius), a low viscosity and good thermal stability. The current article explored the advantages of a synthetic, specifically a BDO fluid, versus a mineral-based HTF. The key product features of a well-designed high temperature HTF being thermal stability, its purity and its heat transfer efficiency. By exploring the physicochemical properties, it was shown that a BDO fluid has a lower kinematic viscosity and can be used in vapour heating, which means the fluid offers better efficiency than a mineral-based HTF.

Lastly, the data collected following real-world usage of these fluids showed that thermal stability can even be detected and differences shown between the formations of carbon deposits in the fluids themselves and thus a lower propensity to foul. Other practical advantages, not discussed in the present article, offered by a synthetic HTF include a longer working life which effectively means that this type of fluid will generally provide better resistance to changes in chemical structure over the life time of the HTF, will need to have fewer change-outs and will offer a cleaner operating system (Hosted by Heat Processing on 2nd December, 2015).

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