



Biodesulfurization of DBT in an integrated system of ultrasonication and biodesulfurization

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Introduction:

Ultra-sonication and Biodesulfurization

- Sonication is a technique for enhancement the kinetics of biochemical processes involving enzymatic or biochemical transformations [1].
- The integration of BDS with ultra-sonication may increase the Biodesulfurization (BDS) performance [2].
- During ultra-sonication, the exposure of liquids to ultrasonic waves of high intensity causes acoustic cavitation that induces better surface chemistry of catalysts by enhanced micro-mixing and oxidation of the organo-sulfur compounds.
- Ultra-sonication can be integrated with the BDS process because it can solubilize the insoluble or slightly soluble organo-sulfur compounds into aqueous solution.
- Especially for bunker oil, which has higher viscosity than gasoline and diesel, the low solubility in aqueous phase might be one of major limitations of BDS. Reducing the viscosity of bunker oil and increasing the contact of bunker oil with biocatalyst is a critical step in BDS. Moreover, hydroxyl radicals and hydrogen peroxide can be formed by the decomposed of water under ultrasound in aqueous solutions [2,3] and this can contribute to oxidation of organosulfur compounds such as the oxidation of thiophenes into sulfones.
- Moreover, the volatile and semi-volatile thioethers and thiophenes can also be decomposed by sonication in the aqueous solution.
- The oxidative desulfurization of liquid fuels can be considerably accelerated by ultrasound treatment.

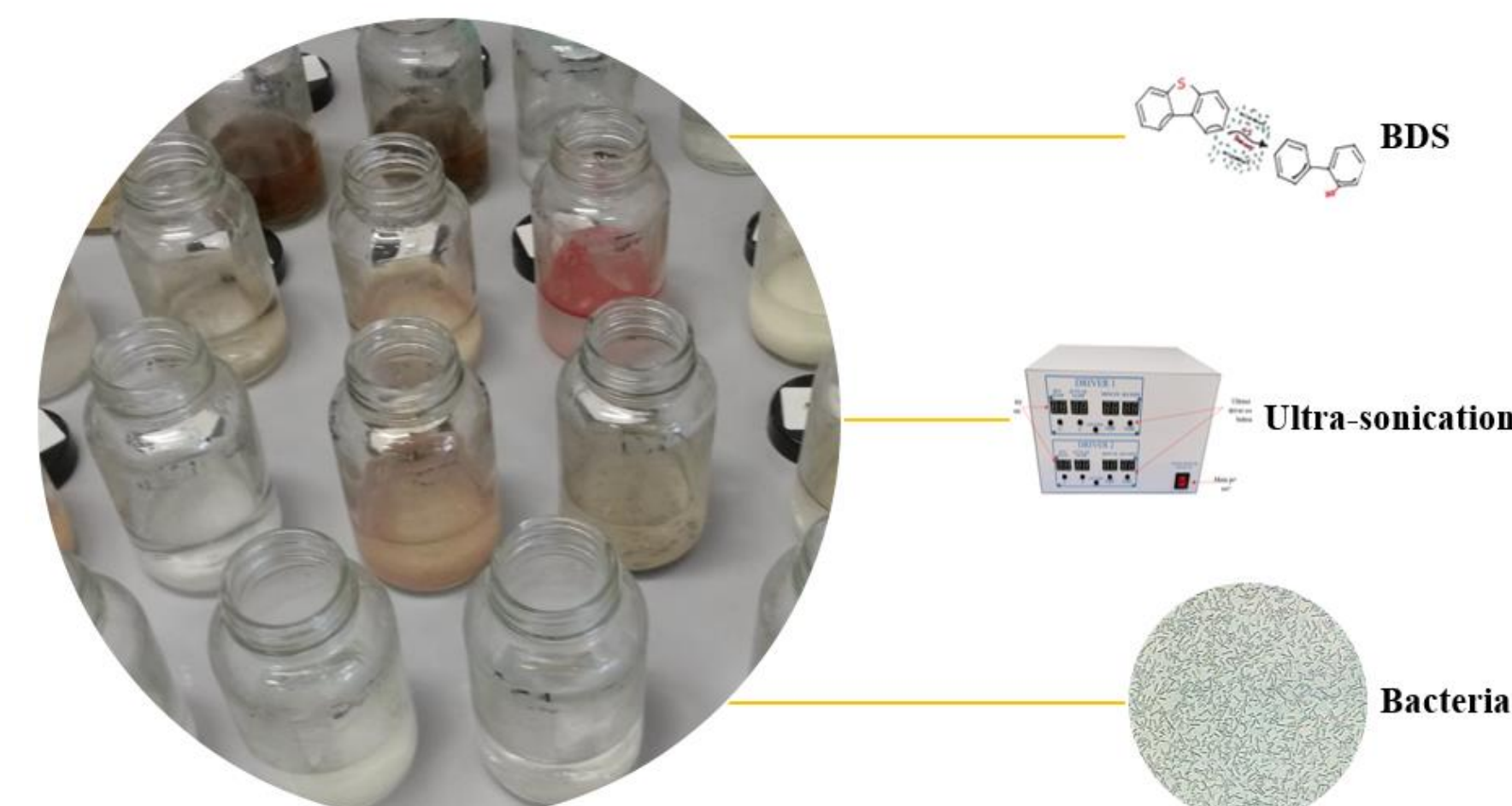


Figure 1. Ultra-sonication of oil for enhancing the BDS process.

Materials and Methods:

(A) Development of a high intensity ultrasonic system for removing sulfur from DBT

- The ultrasonic system was developed to increase the performance of BDS process.

(B) Software for controlling the high intensity ultrasonic system.:

- The software interface to control the ultrasonic system is written in C#. The software development includes the following tasks:
 - Ultrasound control (frequency, voltage or power, pulse duration, continuous or pulse mode, pulse repetition frequency (PRF), delay between exposures, and number of exposures).
 - Temperature measurement.
 - Command history.
 - Design of a modern electronic driving system. The electronic system includes devices of therapeutic ultrasound (signal generator and RF amplifier). The system is hosted in a commercial cart.

Results:

- ❑ A circular unfocused ultrasonic transducer operating at 28 KHz was developed (Figure a and b).
- ❑ A simple system with a single transducer (Figure 2c) was delivered so that to fully cover the sonication area with ultrasounds.
- ❑ In another configuration, 6 ultrasonic transducers (Figure 2d) operating at 28 KHz with a diameter of 35 mm were used.

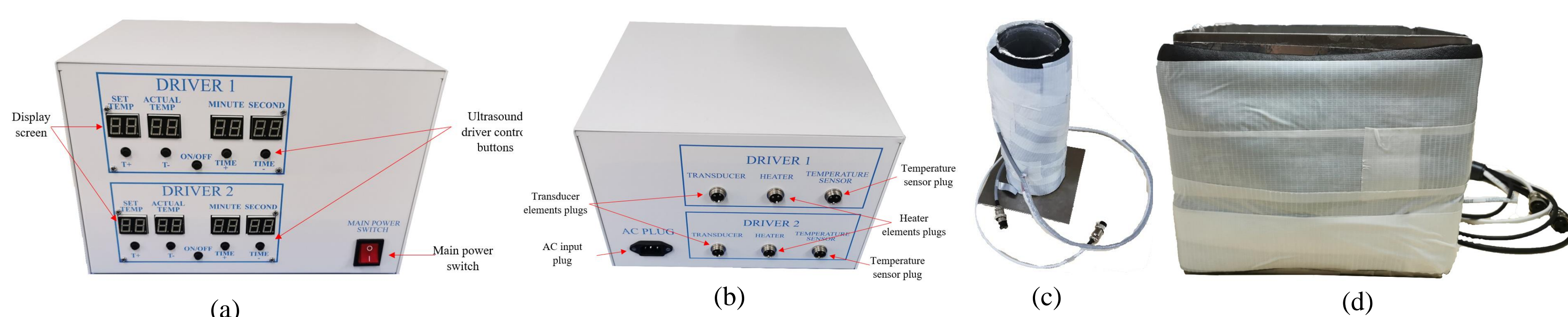


Figure 2. Ultra-sonication system: (a) Electronic system (front view), (b) Electronic system (rear view), (c) Single transducer water tank, (d) Six transducers water tank with the thermal insulation foam.

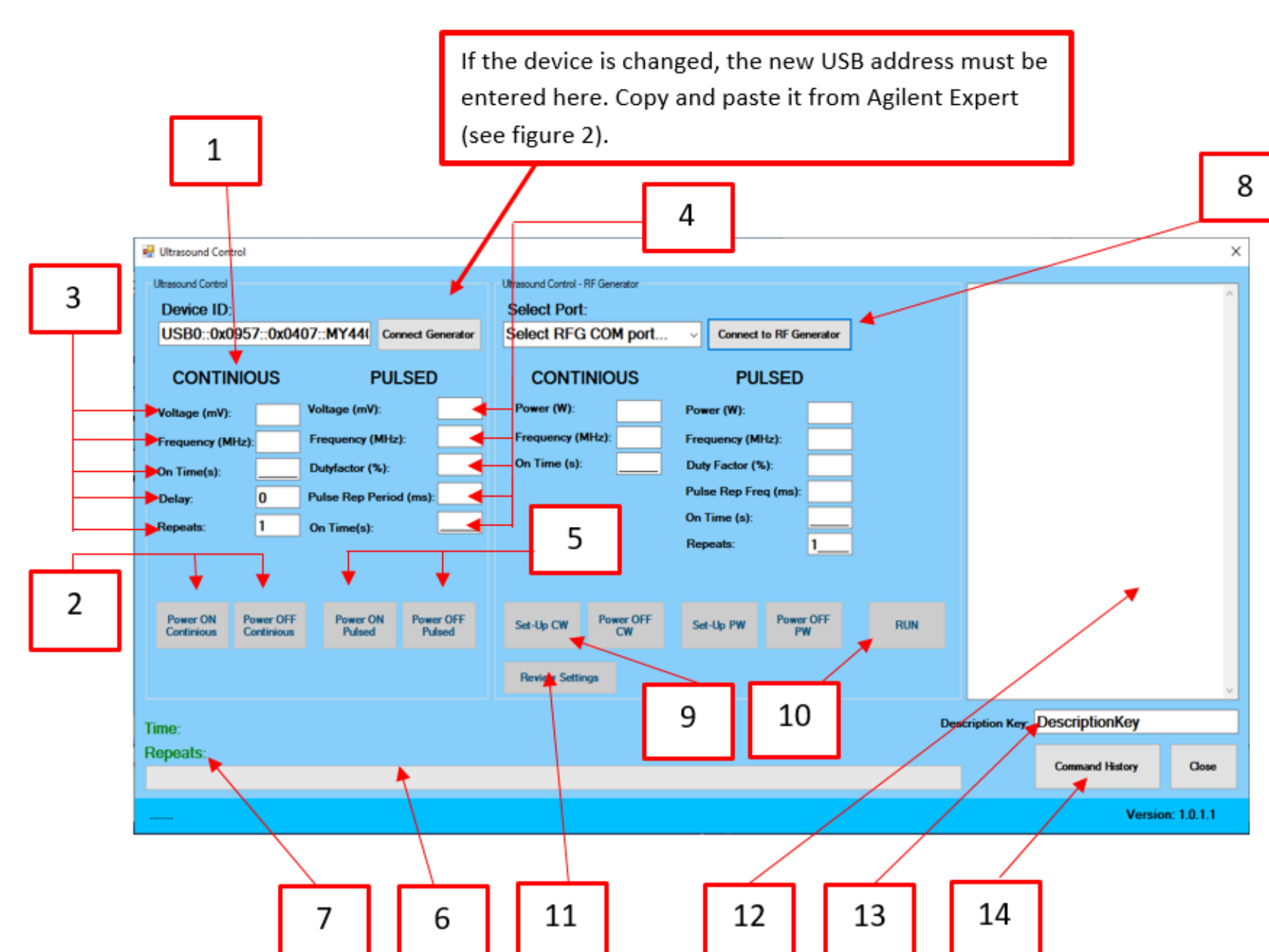


Figure 3. Ultrasound Control User Interface.

- ❑ The ultrasound control user interface controls two different types of generators (Figure 3). The procedure to control the generators is the following:
- ❑ Agilent: In order to control the Agilent signal generator the 'VisaComLib.dll' library was used to send and receive commands from the signal generator. The commands were send in string format to the generator.
- ❑ RFG_100: The RFG_1000 (JJ&A Instruments, USA). It is connected with the computer via a USB interface and can be controlled from the computer by sending commands in string format. In order to interchange string commands with device, a serial com port was opened.

Conclusions:

- ❑ A simple system with a single transducer was developed to be used at a small volume BDS process.
- ❑ A larger container – water tank was developed with six transducers and a thermal insulation foam to cover larger volumes of BDS process.
- ❑ A software for controlling the high intensity ultrasonic system was also developed.

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