Technical Note

SCIENION
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Stable printing of high viscous samples using sciPULSE

Abstract

In many applications using SCIENION's precision dispensing technology, viscosity is an important parameter in the experimental configuration and can hinder the printing performance. Here we introduce sciPULSE High Viscosity as an easy dispensing solution with the sciFLEXARRAYERs platforms. Using highly viscous reference samples, such as glycerol and polyethylene glycol (PEG), it could be demonstrated that the sciPULSE High Viscosity plug-in solution overcomes the challenges of dispensing viscous samples in both the low and high volume range.

Introduction

Viscosity is a measure of a fluid's resistance to deformation at a given rate, specified in millipascal per second (mPa*s) and is often referred to the thickness of a fluid[1]. Fluids with a high viscosity like higher concentrated glycerol, PEG or sample containing serum are less flowable which might impact the aspiration and dispensing properties (Figure 1).

Figure 1 Liquids with different viscosities. The liquid on the left has lower viscosity than the liquid on the right and impacts how easily a fluid flows.Image taken from *https://de.wikipedia.org/wiki/Viskosität 20220117*

sciPULSE High Viscosity plug-in solution

Besides the possibility of adjusting droplet volumes by using different sizes of PDCs and reliable droplet formation by using specially coated PDCs, the sciPULSE solution enables the dispensing of high viscosity samples.

sciPULSE is a specific hardware device including software that enables adjustment of additional pulse settings compared to the standard sciFLEX software (Figure 2). Predefined packages can be selected according to the specific customer application, such as for dispensing low drop volumes or highly viscous fluids. High viscosity samples can be printed in both low or high volume ranges by applying the special pulse shapes HV01 & HV02. Additionally, relative humidity, voltage, and temperature need to be fine-tuned to achieve optimal spot quality on a variety of surfaces.

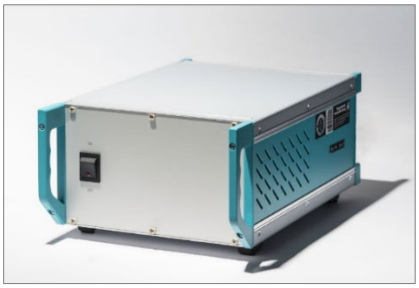

Figure 2: sciPULSE device: The device is a plug-in device, can be used on all sciFLEXARRAYERs and enables the 1-channel usage of different software package for dispensing of different application, such as low volumes and high viscosity samples

Depending on the selected application package VISC01 or VISC02, droplets with low drop volume (< 200 pL) can be generated for viscosities up to 22.5 mPa*s or high drop volumes (> 400 pL) for viscosities up to 10.8 mPa*s, respectively.

Materials and methods

Precision dispensing of viscous fluids using sciPULSE VISC01 and VISC02

20 – 70% Glycerol, 70 – 99% ethylene glycol and 20% PEG 6,000 in water have been prepared for the experimental runs. The dynamic viscosity for all viscous samples was measured using the viscometer from Anton Paar AMVn at a temperature of 20°C.

Samples were printed using the sciFLEXARRAYER S12 with a PDC 80 and applying sciPULSE VISC01 for dispensing drop volumes lower than 200 pL and VISC02 for dispensing drop volumes higher than 400 pL. Arrays were printed on epoxy glass slides. The drop volume and the flight path were examined using the AutoDropControl in the sciFLEX software.

Results and discussion

To analyze the dispensing accuracy and reliability of viscous samples, the achievable drop volume, the drop stability, the drop trajectory as well as the absence of satellite drops were determined, with either a standard pulse or the sciPULSE application package VISC01 or VISCO2.

Applying VISC01

sciPULSE VISC01 allows stable drop formation of the following viscous reference samples in the low drop volume range (up to 200 pL depending on the PDC size):

- up to 70 % glycerol (22.5 mPa*s),
- 99 % ethylene glycol (20.7 mPa*s),
- 20 % PEG 6,000 (12.7 mPa*s)

Applying the standard pulse enables stable drop formation of significantly lower viscous samples:

- up to 40% glycerol (< 5 mPa*s)
- 30% ethylene glycol (< 6 mPa*s)

Results are shown in Figure 3. Standard pulse settings led to no stable drop formation when samples with higher concentrations than > 50% glycerol, 50% ethylene glycol or 20% PEG 6,000 were dispensed. Instead of a stable single droplet, the dispensed liquid gets split into multiple droplets until no more drops can be formed. A significantly lower drop velocity, shown in the shorter drop distance to the dispenser orifice as observed in 50 % glycerol sample with standard pulse settings (yellow frame) represents a significantly higher risk of drop deflection or drop formation stops completely during the run.

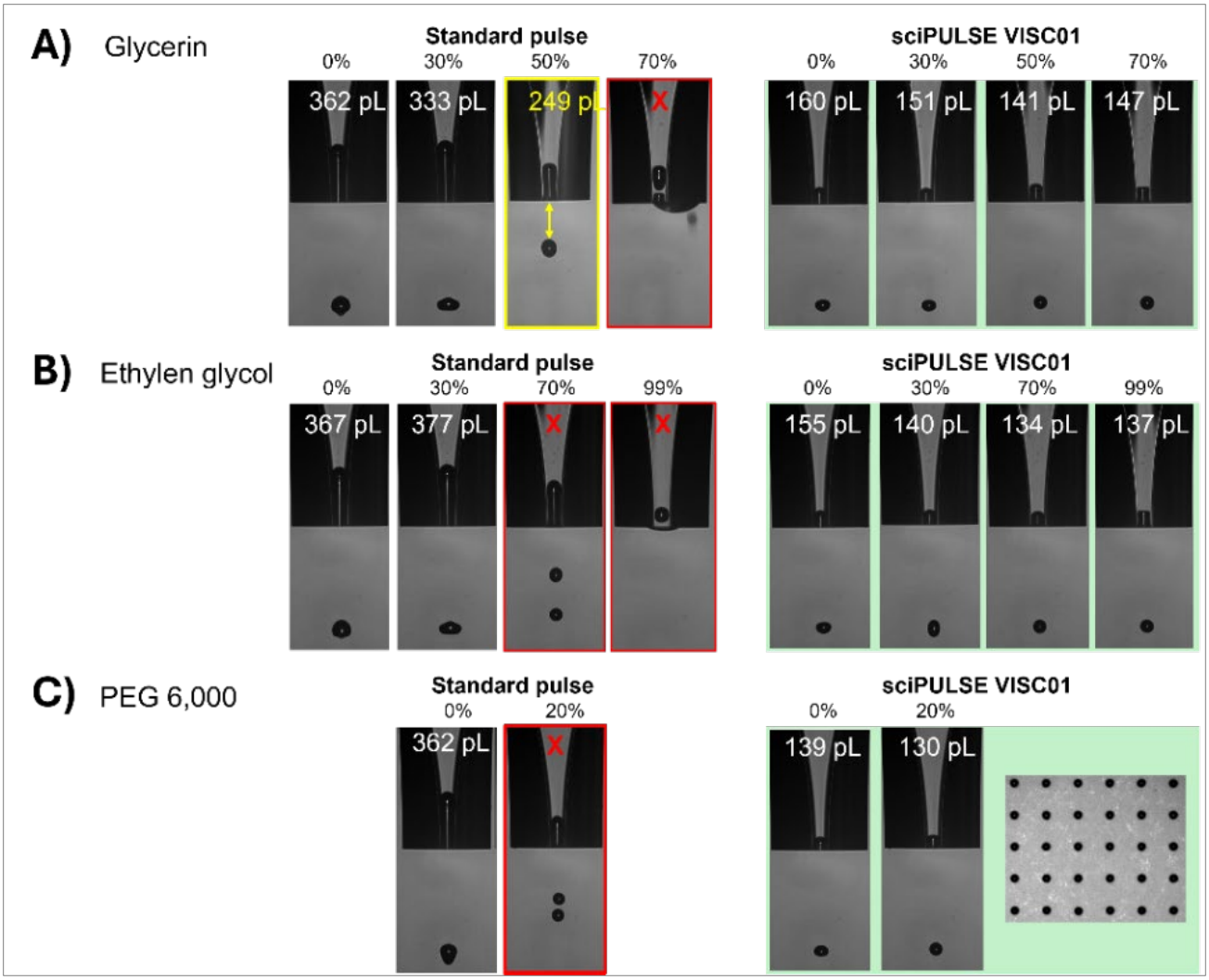

Figure 3: sciPULSE VISC01 enables printing of viscous reference samples in the low drop volume range. Up to 70% glycerol (A), 99 % ethylene glycol (B) and 20% PEG 6,000 (C) were dispensed with the application package VISC01 (right panels), whereas applying the standard pulse (left panels) no stable drop formation could be detected for samples with higher concentrations than > 50% glycerol, 50% ethylene glycol or 20% PEG 6,000. Instead of a stable single droplet, the dispensed liquid gets split into multiple droplets (B,C 70% ethylene glycol, 20% PEG 6,000), until no more drop can be formed (A,B 70% glycerin, 99% ethylene glycol) A significant lower drop velocity, shown in the shorter drop distance to the dispenser orifice as observed in 50 % glycerol sample with standard pulse settings (A, 50% glycerin) represents a significant higher risk of drop deflection or drop formation stops completely during the run. (C, right panel) An exemplary 5 X 6 dispensed array is shown when VISC01 is applied. Please note that the standard pulse can only be used for drop volumes higher than 220 pL

Applying VISC02

Using sciPULSE VISC02 allows stable drop formation of viscous samples in the higher drop volume range with drop volumes > 400 pL depending on the used PDC size.
Figure 4 compares the achieved drop volume with sciPULSE VISC01 vs. sciPULSE VISC02 using 60% glycerol.

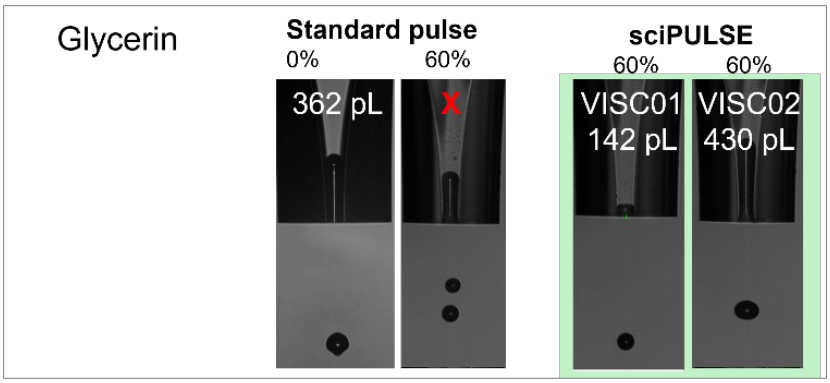

Figure 4: sciPULSE VISC02 enables printing of viscous reference samples in the higher drop volume range. Up to 60% glycerol was dispensed with the application package VISC01 for lower drop volumes (second right panel), or VISC02 for higher drop volumes (right panel) whereas standard pulse (left 2 panels) led to no stable drop formation. Instead of a stable single droplet, the dispensed liquid gets split into multiple droplets.

Conclusion and future direction

Applying sciPULSE VISC01 and VISC02 enables the stable printing of viscous samples up to 22.5 mPA*s or 10.8 mPA*s which cannot be printed using standard pulse parameters.

- Stable & accurate dispensing of viscous liquids can be ensured without the occurrence of printing instabilities such as multiple droplets, and deviated drop flight up to no drop formation.

The sciPULSE plug-in solution with specific application packages such as High Viscosity (VISC01 and VISC02), Ultra Low Volume (ULV) or Low Volume (LV) in combination with the right PDC extends the dispensing capabilities of SCIENION's sciFLEXARRAYER platforms. In this way, challenging samples for specific applications, such as organic solvents, carbohydrates or polymers can be printed.

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