OSR-Tool User Manual

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Table of contents

Table of contents i
Introduction 1
  Benefits of OSR-Tool 1
  Dependencies 2
Accessing the OSR-Tool 2
  Logging In / Creating an Account / Password Recovery 2
User Interface Overview 3
  Default Dashboard Overview 3
  Active Dashboard Overview 4
Getting Started 10
  Preparing Your Files 10
  Adding Files to OSR-Tool 11
Performing Analysis Using OSR-Tool 12
  Accessing the OSR Analysis Button 12
  Understanding the Run Settings Options 12
  Running Analysis and Obtaining Results 13
  Navigating Between Computed Parameters and Original Files 13
    My Files 14
    Intercycle Analysis 14
    Intracycle Analysis 16
Exporting Data 17
Appendix A: Viscoelasticity from Oscillatory Shear Test 18
  Conventional Strain-sweep Viscoelastic Moduli 18
  Fourier Transform (FT) Rheology 19
  Stress Decomposition (SD) Technique 19
  Chebyshev Parameters Approach 19
  Perfect Plastic Dissipation Ratio 20

Sequence of Physical Processes (SPP) Technique 21
Acknowledgements 23
References 24

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Introduction

OSR-Tool is a web-based (JavaScript) tool for processing oscillatory shear (time-strain-stress) rheological data, such as data obtained from large amplitude oscillatory shear (LAOS) experiments, cycle sweep, oscillatory shear simulation, or other oscillatory shear based experimental or simulation protocols. It computes a wide array of viscoelastic parameters from different theoretical approaches, including those commonly found in Fourier-transform (FT) rheology, stress decomposition, Chebyshev parameters, and sequence of physical processes (SPP) approaches, all within an easy, non-technical workflow. A brief description of viscoelasticity under small amplitude oscillatory shear (SAOS) and LAOS is provided in Appendix A. A more detailed description can be found in the referenced articles.

Benefits of OSR-Tool

- **Wide and Versatile Analysis: OSR-Tool** supports a wide array of analysis techniques, such as Fourier Transform (FT) rheology, Lissajous curve analysis, stress decomposition, Chebyshev parameters, and Sequence of Physical Processes (SPP) techniques, along with customization options.
- **No Installation Required: OSR-Tool** operates entirely in the browser and does not require installation.
- **Data Privacy:** All **OSR-Tool** operations are handled within the user's device. The analyzed data is not transmitted to a server.
- **Multiple File Input:** Multiple files can be processed at once. The number of files that can be analyzed simultaneously is only limited by system resources.
- **Dynamic Import and Export of Files:** Multi-file selection and drag-and-drop are supported. Arbitrary column arrangements can be exported, and multiple files can be combined during the export of computed parameters.
- **Easy to Use and Customize: OSR-Tool** features a clear and concise user interface. Several parameters that control computation can be adjusted by the user.

Dependencies

OSR-Tool depends on the libraries listed in Table 1 to work.

Table 1: External library dependencies of **OSR-Tool**

Library name	License
SheetJS	MIT License
JSZip	MIT License
dsp.js	Apache License 2.0
google-chart	Apache License 2.0

Accessing the OSR-Tool

OSR-Tool is based on HTML and JavaScript and is accessible from https://edufyx.com/OSR/ from all modern browsers. While full analysis and visualization of the analyzed data both as spreadsheet or as graphs is possible without an account, few operations such as saving graphed images or exporting computed parameters to device memory requires an account.

Logging In / Creating an Account / Password Recovery

Account login, creation, or recovery is possible from the same **OSR-Tool** page or alternatively through https://edufyx.com/login/.

User Interface Overview

Default Dashboard Overview

Figure 1 shows the interface of **OSR-Tool** homepage once it is fully loaded by the browser. This is the default view when no file is currently loaded by the program.

The default interface provides the following functionalities:

- **Quick User Guide**: Contains instructions on quickly using the **OSR-Tool**.
- **File Selector**: A button for selecting a file from the device folder. It allows selecting specific file types, and multiple files can be selected at once. However, only spreadsheet files with .XLS, .XLSX, .XLSM, and .CSV extensions are processed and loaded; other file types are ignored.
- **File Drop Area**: Enables file input via drag-and-drop. Dropping multiple files is supported.
- **Create new**: A button that allows manual entry of data.
- **Menu**: A button for accessing additional actions.

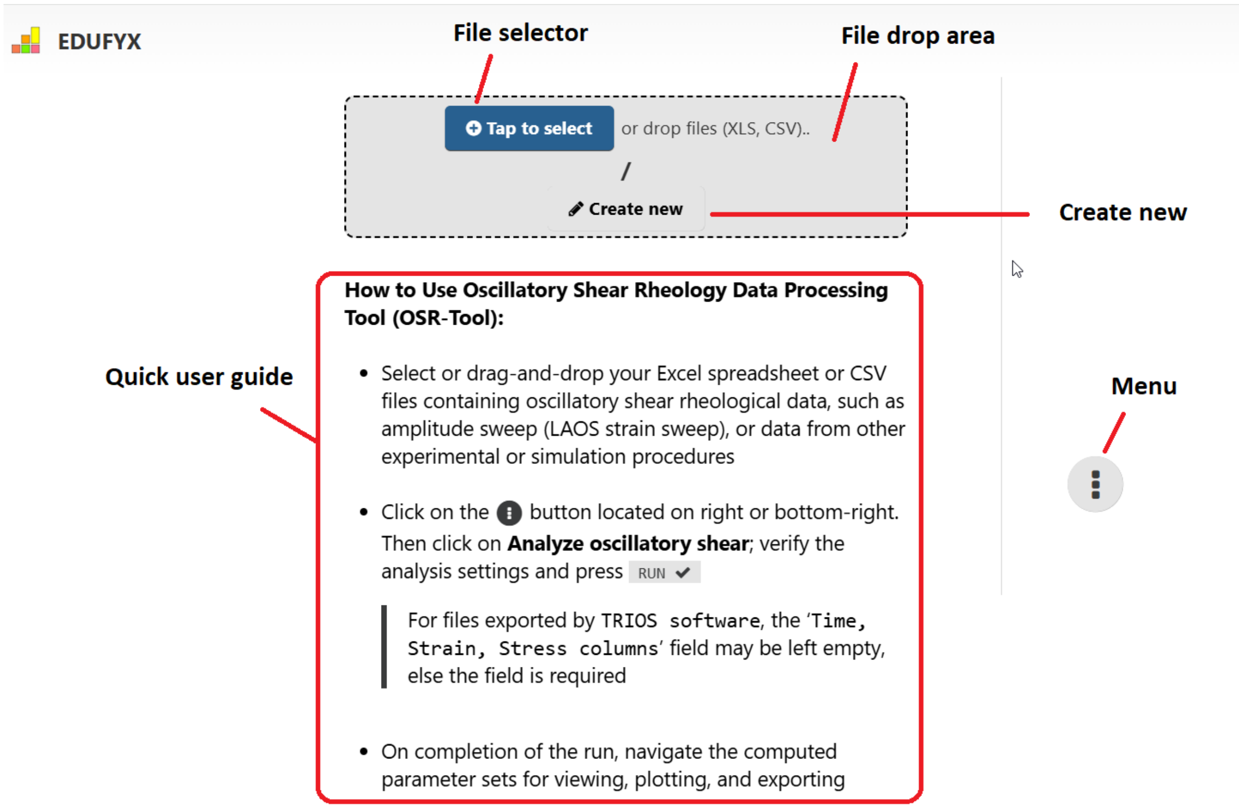

Figure 1: The **OSR-Tool** default dashboard view

Active Dashboard Overview

Once one or more valid files have been loaded using the file selector button or by drag-and-drop, new widgets will appear and the interface is changed to reflect an active file selection. Figure 2 shows the active interface of the **OSR-Tool**, which appears after one or more valid files have been loaded successfully.

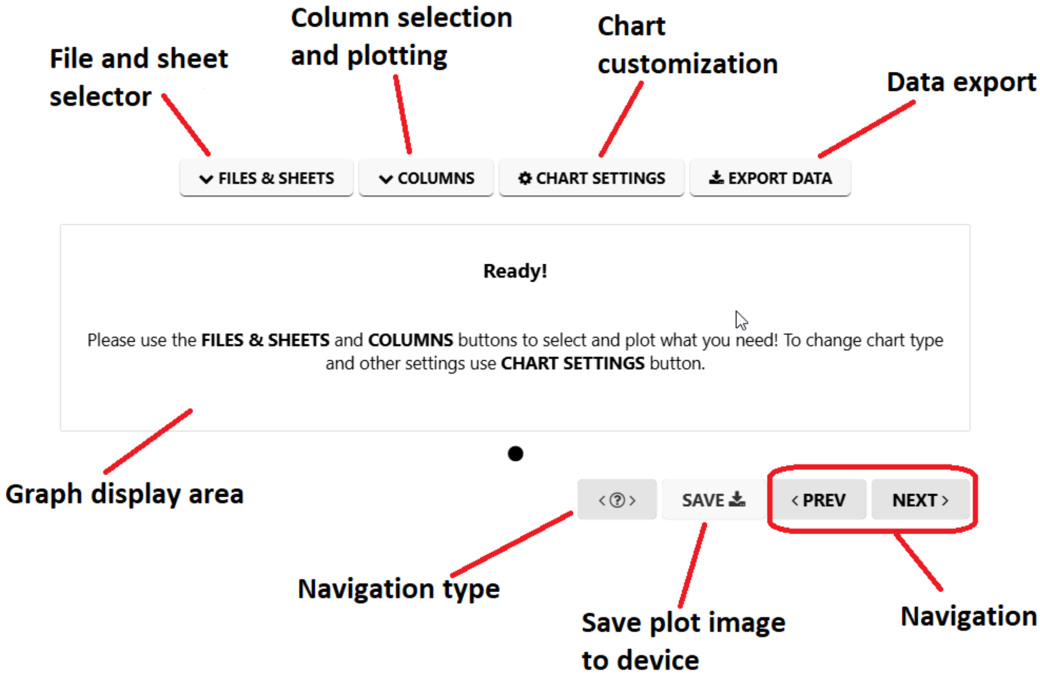

Figure 2: Additional widgets displayed in active interface of **OSR-Tool**

The active interface exposes widgets that offer the following functionalities:

- **File and Sheet Selector:** A button that allows for changing the currently active file and sheet. It also exposes another button that allows for editing the currently selected sheet. Even though multiple files can be selected, only one sheet and its corresponding file are active at a time.

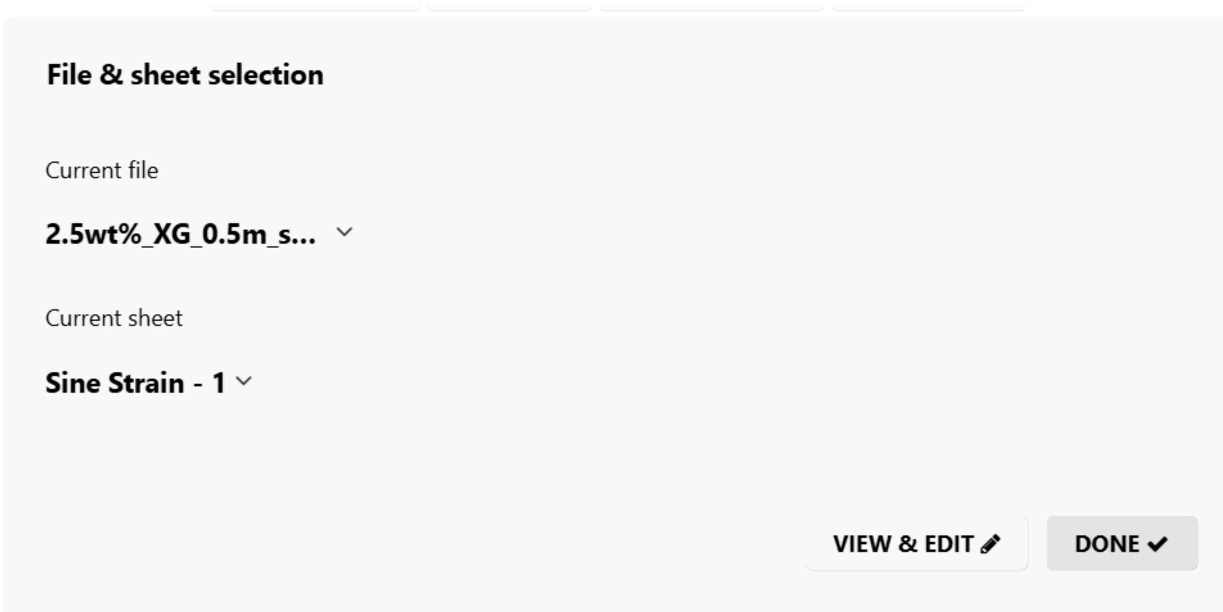

Figure 3: File and sheet selector widget

- **Column Selection and Plotting:** A button that allows for selecting columns for plotting. The first selection is used as the x-axis, while subsequent selections are regarded as the y-axis.

Figure 4: Column selector and plotting widget view

- **Chart Customization:** A button that allows for customization of the chart, such as changing the chart type, title, axis titles, size, and so on. Supported chart types include line, scatter, bar, pie, column, histogram, area, and stepped area charts.

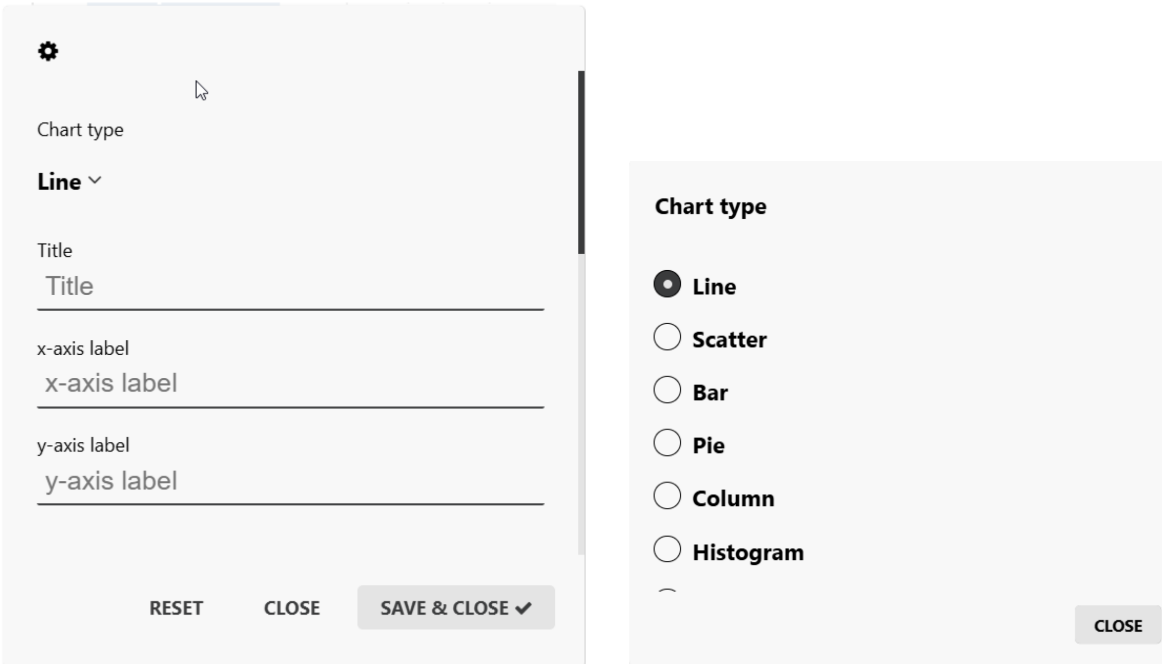

Figure 5: Settings (left) and chart type selector (right) widgets

- **Navigation Type:** A button to switch between 'File' or 'Sheet' navigation. In 'File' mode, pressing the left or right navigation goes from one file to another. This is only possible if the name of the current sheet also exists in the other file. In 'Sheet' mode, these buttons navigate to the next or previous sheet in the currently active file.
- **Data Export:** A button that allows for selection of columns and optional spacing for saving to the device. Available columns (based on the currently selected sheet) and spacing may be arranged in any order for saving as a comma-separated file and may be viewed or edited using external spreadsheet programs.
- **Graph Display Area:** Plots appear in this area.

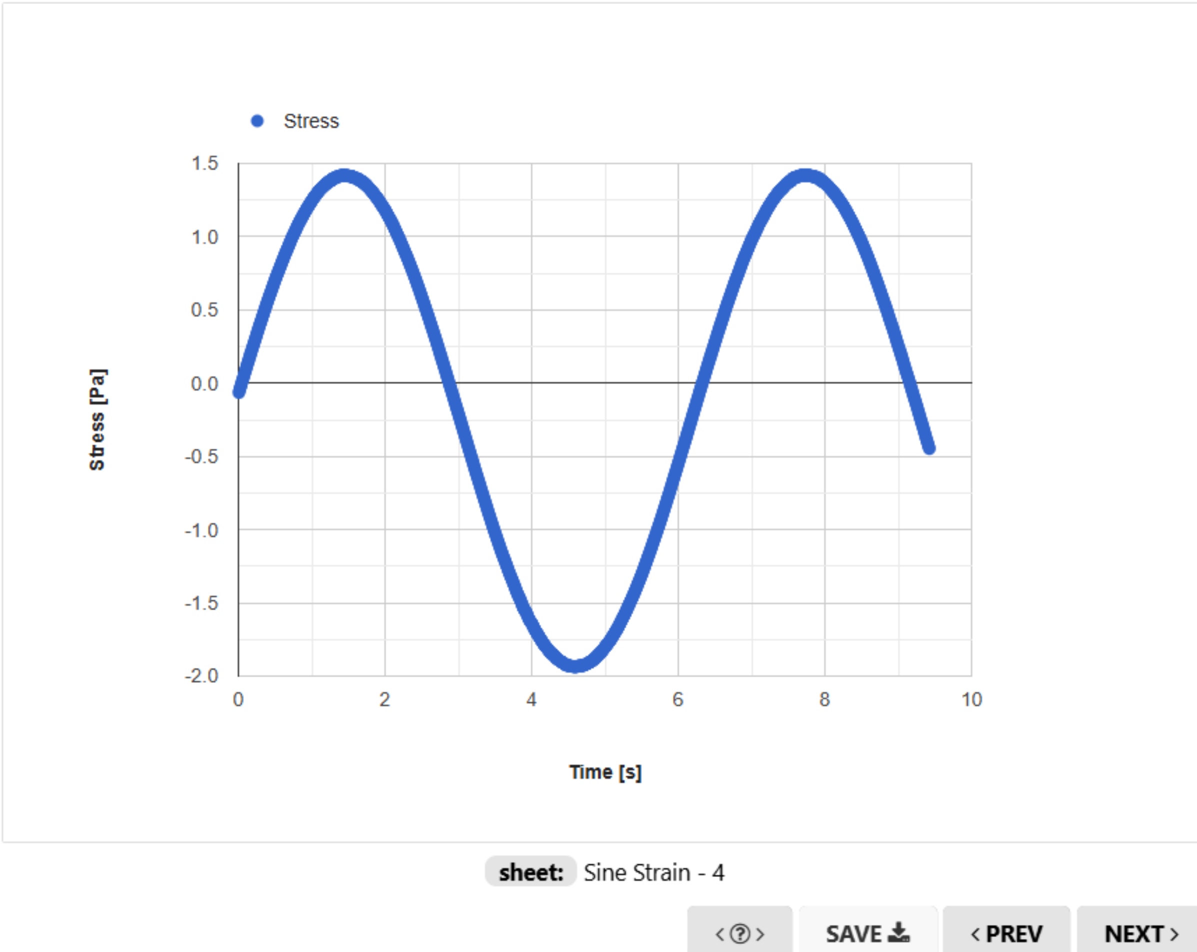

Figure 6: Plot widget

- **Save Plot Image to Device:** A button to save the current plot to the device as an image file.
- **Navigation:** Buttons to navigate to the right or left of the current selection (file or sheet). Navigation also updates the plot when there is an active plot.

Getting Started

Preparing Your Files

To successfully perform an analysis using the **OSR-Tool**, a valid spreadsheet file with the extension .XLS, .XLSX, .XLSM, or .CSV is required. The file needs to contain at least a sheet with content that meets the following criteria:

- It must contain a minimum of three columns corresponding to time, strain, and stress.
- Must contain at least one full cycle of oscillation.
- These columns may be arranged in any order; however, each column must contain consistent data and should not be mixed with different data types.
- The number of samples per cycle must be a power of two (i.e., a cycle must contain 2^p data points where p is an integer).
- Column labels may be provided but are not required.
- The experiment or simulation that generated the data is assumed to be strain-controlled.

	A	B	C	D	E
1	Sine Strain - 4				
2	Step time	Stress	Strain	Normal force	Temperature
3	s	Pa	%	N	°C
4	0.00618156	-0.0651732	-0.192621	0.0298818	36.93
5	0.0123461	-0.0532389	-0.183001	0.0298761	36.93
6	0.0185107	-0.0420193	-0.173374	0.0298662	36.93
7	0.0246752	-0.0319651	-0.163741	0.0298583	36.93
8	0.0308398	-0.0218316	-0.154101	0.0298602	36.93
9	0.0370043	-0.0117971	-0.144456	0.0298642	36.93
10	0.0429858	-0.00131586	-0.134805	0.0298688	36.93

+ COL + ROW × SAVE ⁝

Figure 7: A valid file needs to contain a sheet with time, strain, and stress columns

If no sheet within the selected files meets this criterion, processing may end with an error.

Adding Files to OSR-Tool

The file selection button or drag-and-drop functionality can be used to add files to the **OSR-Tool** for analysis. All files for analysis in a particular batch must be added together; i.e., they must exist in the same folder and be selected at once when using the selection button, or dragged and dropped simultaneously when using the drag-and-drop feature. When a new batch of files is added to the **OSR-Tool**, previously added files are removed.

Performing Analysis Using OSR-Tool

Accessing the OSR Analysis Button

After adding files to the **OSR-Tool**, ensure that the added files contain valid oscillatory shear data by locating and plotting **strain vs. time**, **stress vs. time**, or **stress vs. strain** plots using the relevant buttons, which should appear in the active interface. This validation is optional and may be skipped.

For the actual analysis, click on the menu button shown in Figure 1, then click on the **'Analyze Oscillatory Shear'** option. Once done, the **Run Settings** window will open.

Understanding the Run Settings Options

The run settings present several adjustable parameters that control how the **OSR-Tool** computes various viscoelastic parameters. The following options are available for customization:

- **Stress Filtering:** An on/off option that controls whether the stress is filtered by the odd harmonics or not.
- **Odd Harmonics Count:** A numeric input specifying how many odd harmonics, beginning with the first harmonic, to consider when the stress filtering option is enabled.
- **Use Last Cycle:** An on/off option that, when enabled, causes the last cycle of the stress data to be used for analysis. This is meaningful if the oscillation consists of more than one cycle.
- **Normalize Transients:** An on/off option that, when enabled, normalizes all data in the 'Transient' section of the results by their maximum values.
- **Time, Strain, Stress Columns:** A text input of three comma-separated numbers indicating which columns contain the time, strain, and stress data. For example, entering **'1, 3, 2'** would imply that column 1 contains the time, 3 contains the strain, and 2 contains the stress data.

> **NOTE:** The **Time, Strain, Stress Columns** may be left empty for amplitude sweep (LAOS) experiment data directly exported using **TRIOS software (TA Instruments, USA)** otherwise the field is required.

- **Record Harmonics Up To:** A numeric input specifying how many harmonics are recorded in the results.
- **Record I_n/I_1 for n Up To:** A numeric input specifying how many higher odd harmonics, divided by the first harmonic (I_1), are recorded in the results.

Running Analysis and Obtaining Results

Once the run settings are adjusted to the desired values, press the Run button to complete the analysis process. Upon completion, a new set of widgets becomes visible in the **OSR-Tool** interface, allowing navigation between two sets of computed parameters as well as the original input files.

Navigating Between Computed Parameters and Original Files

The original files and the computed parameters are organized into three categories which can be activated by a click on the corresponding button. The access buttons are shown in Figure 8.

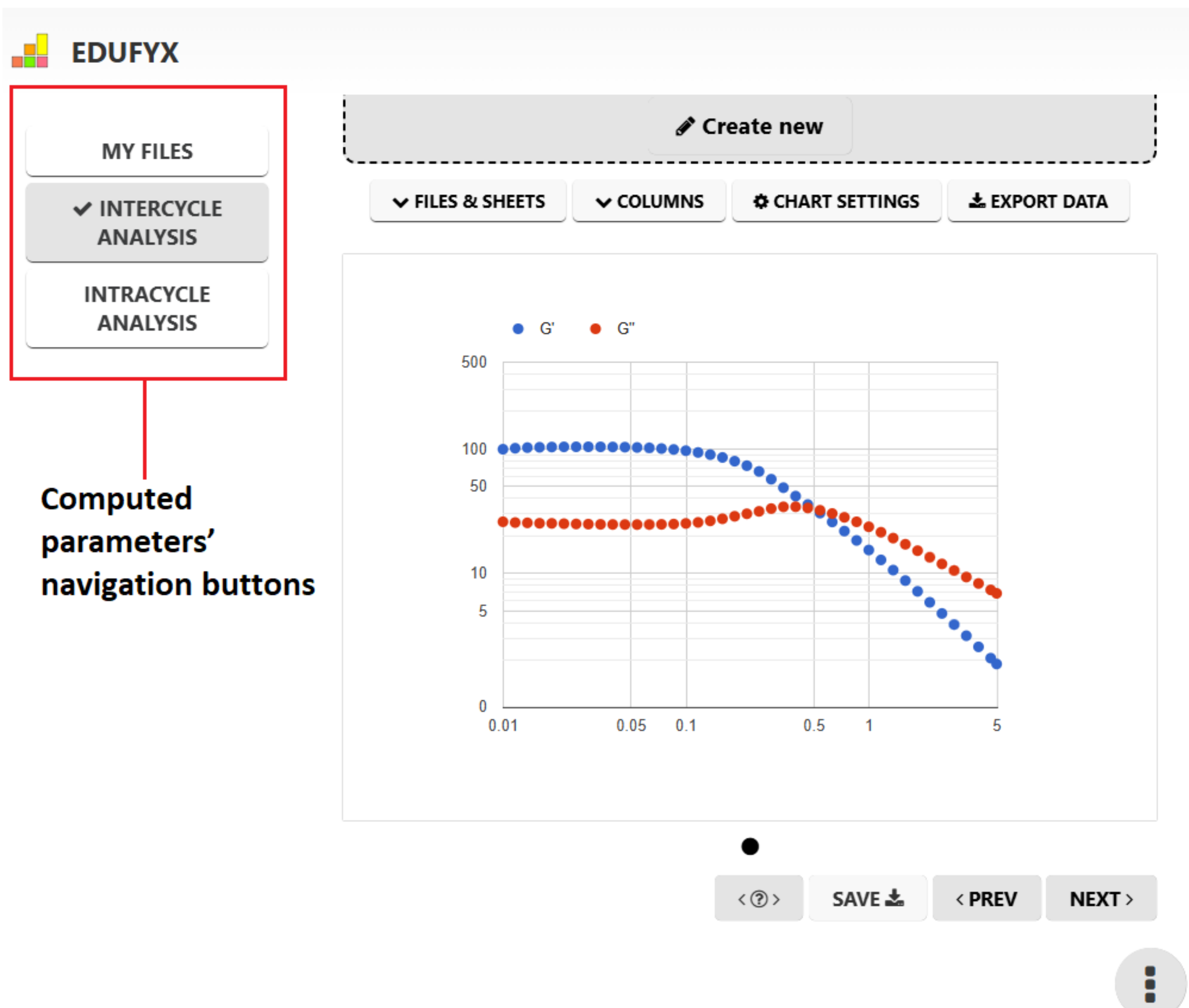

Figure 8: My files and computed parameters widget

My Files

This contains the original input files.

Intercycle Analysis

This contains properties that are usually compared against the strain amplitude or frequency, such as the elastic and viscous moduli (G' and G''). These parameters are summarized in Table 2.

Table 2: Parameters grouped under the "INTERCYCLE ANALYSIS" category

Parameter name	**Label in OSR-Tool**	**Common symbol**	**SI Unit**
Sequence number	Sequence No.	SN	-
Strain amplitude	Strain amplitude	γ_{o}	-
Storage modulus	G'	G'	Pa
Loss modulus	G"	G''	Pa
Complex modulus	|G*|	$\|G^*\|$	Pa
Ratio of third to the first harmonic intensity	I_{3/1}	I_3/I_1	-
Nonlinearity	Q	Q	-
Minimum-strain modulus	G_{M}	G'_{M}	Pa
Large-strain modulus	G_{L}	G'_{L}	Pa
Minimum-rate dynamic viscosity	Eta_{M}	η'_{M}	Pa·s
Large-rate dynamic viscosity	Eta_{L}	η'_{L}	Pa·s
Maximum transient storage modulus	G'_{t, max}	$G'_{\mathrm{t,max}}$	Pa
Maximum transient loss modulus	G"_{t, max}	$G''_{\mathrm{t,max}}$	Pa
Minimum transient storage modulus	G'_{t, min}	$G'_{\mathrm{t,min}}$	Pa
Minimum transient loss modulus	G"_{t, min}	$G''_{\mathrm{t,min}}$	Pa
Stiffening ratio	Stiffening ratio	S	-
Thickening ratio	Thickening ratio	T	-
Dissipation ratio	Dissipation ratio	ϕ	-
Angular frequency	Frequency	ω	rad/s
Stress amplitude	Stress_{max}	σ_{o}	Pa
Tangent of the phase angle	Tan(delta)	$\mathrm{Tan}(\delta)$	-
Dynamic viscosity	Eta'	η'	Pa·s
Out of phase component of $\|\eta*\|$	Eta"	η''	Pa·s
Complex viscosity	|Eta*|	$\|\eta^*\|$	Pa·s
First-harmonic elastic Chebyshev coefficient	Chebyshev e_{1}	e_1	Pa

First-harmonic viscous Chebyshev coefficient	Chebyshev v_{1}	v_1	Pa·s
Third-harmonic elastic Chebyshev coefficient	Chebyshev e_{3}	e_3	Pa
Third-harmonic viscous Chebyshev coefficient	Chebyshev v_{3}	v_3	Pa·s
Ratio of the third to the first harmonic elastic Chebyshev coefficient	Chebyshev e_{3/1}	$e_{3/1}$	-
Ratio of the third to the first harmonic viscous Chebyshev coefficient	Chebyshev v_{3/1}	$v_{3/1}$	-

Intracycle Analysis

These contain parameters that are usually compared against time at any strain amplitude. They are saved at each strain amplitude and across all strain amplitudes contained in the input files. These parameters are listed in Table 3.

Table 3: Parameters grouped under the "INTRACYCLE ANALYSIS" category

Parameter name	**Label in OSR-Tool**	**Common symbol**	**SI Unit**
Time	Time	t	s
Strain	Strain	γ	-
Strain rate	Strain rate	$\dot{\gamma}$	1/s
Elastic contribution to the total stress	Elastic stress (SD)	σ_{E}	Pa
Viscous contribution to the total stress	Viscous stress (SD)	σ_{V}	Pa
Transient storage modulus	G'_{t}	G'_{t}	Pa
Transient loss modulus	G"_{t}	G''_{t}	Pa
Time rate of change of the transient storage modulus	dG'_{t}/dt	$\frac{dG'_{\mathrm{t}}}{dt}$	Pa/s
Time rate of change of the transient loss modulus	dG"_{t}/dt	$\frac{dG''_{\mathrm{t}}}{dt}$	Pa/s
Harmonic number	Harmonic number	n	-
Harmonic intensity	Harmonic intensity	I_n	-
Tangent of the transient phase angle	Tan(delta)_{t}	$\mathrm{Tan}(\delta_{\mathrm{t}})$	-

Exporting Data

Click on the data export button and select the columns for export. Columns and spacing can be arranged arbitrarily for exporting to external memory. When similar files are present, the selected columns are combined into a single file, which may be more convenient for plotting using an external program. For clarity, a desired amount of spacing may be inserted during export.

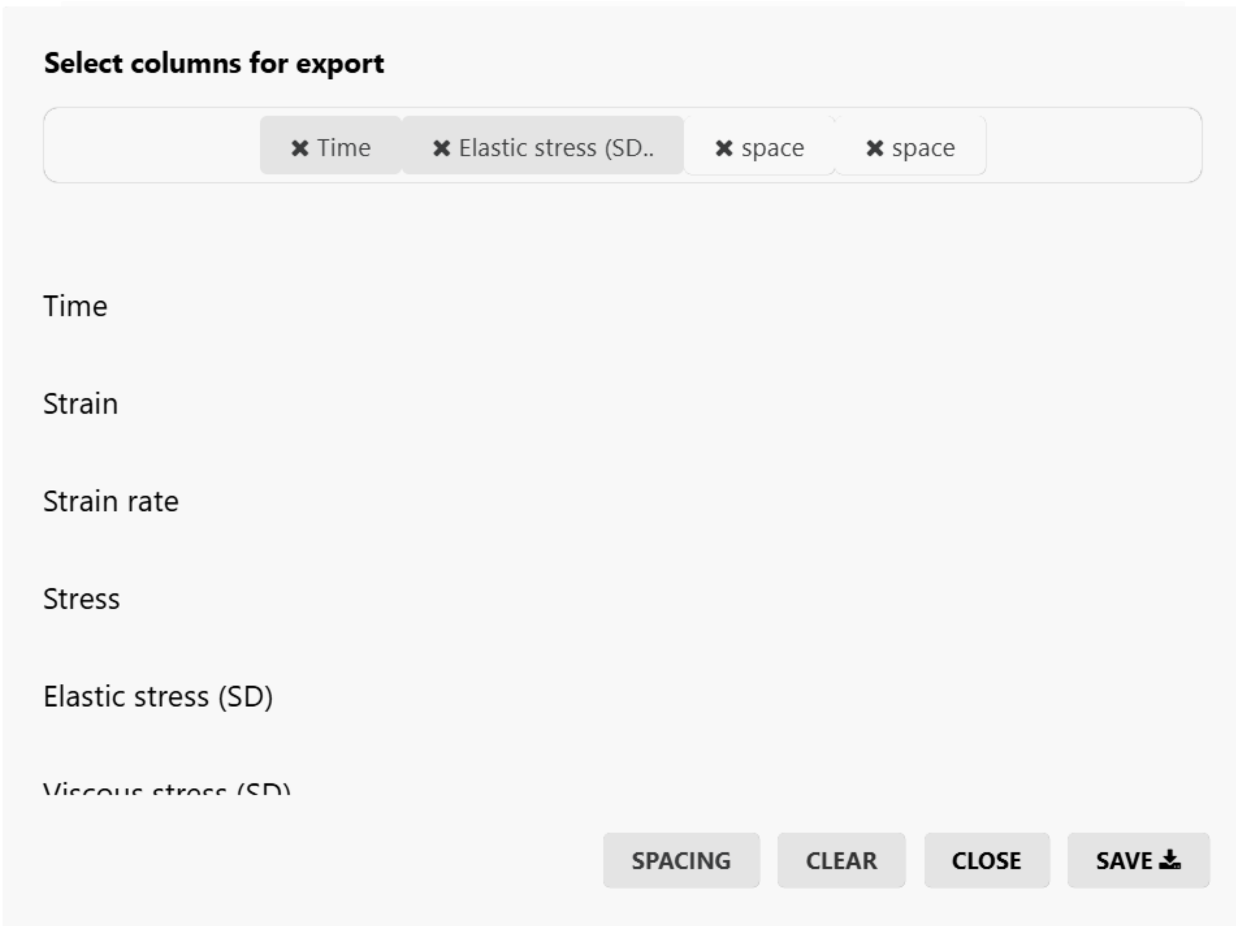

Figure 9: Columns and spacing can be arranged arbitrarily for saving to device memory

Appendix A: Viscoelasticity from Oscillatory Shear Test

Conventional Strain-sweep Viscoelastic Moduli

Oscillatory shear test, such as small amplitude oscillatory shear (SAOS) and large amplitude oscillatory shear (LAOS) (Hyun et al., 2011), is a popular technique for characterizing viscoelasticity of numerous classes of materials such as hydrogels (Nnyigide et al., 2024). In oscillatory shear test, a time varying strain $\gamma(t)$ of some strain amplitude γ_{o} and frequency ω is applied on a material. This may be represented as:

$$\gamma(t) = \gamma_{\text{o}} \sin(\omega t)$$

Therefore, the strain rate is:

$$\dot{\gamma}(t) = \omega \gamma_{\text{o}} \cos(\omega t)$$

If γ_{o} is small enough, the material's stress response is linear and may be represented as $\sigma(t) = \sigma_{\text{o}} \sin(\omega t + \delta)$, where δ is some phase-shift relative to the strain signal.

The stress response may be further be expanded in terms of material functions as follows:

$$\sigma(t) = \gamma_{\text{o}}[G'(\omega)\, sin(\omega t) + G''(\omega)\, cos(\omega t)] = G'(\omega)\gamma(t) + \frac{G''(\omega)}{\omega}\dot{\gamma}(t)$$

where G' and G'' represents storage modulus and loss modulus respectively and are given by:

$$G' = \frac{\sigma_{\text{o}}}{\gamma_{\text{o}}} \cos\delta\,;\; G'' = \frac{\sigma_{\text{o}}}{\gamma_{\text{o}}} \sin\delta$$

with the σ_{o} representing the stress amplitude.

At large strain amplitude, the stress response is nonlinear and is generally represented using a Fourier series:

$$\sigma(t) = \gamma_{\text{o}} \sum_{n,\text{odd}} [G_n'(\omega, \gamma_{\text{o}}) \sin(n\omega t) + G_n''(\omega, \gamma_{\text{o}}) \cos(n\omega t)]$$

where G_n' and G_n'' represents the *n*th-harmonic storage and loss moduli. The first-harmonic storage and loss moduli (G_1' and G_1'') which are often reported simply as G' and G'' in many commercial rheometers have been used as longstanding conventional material measure of viscoelasticity.

Fourier Transform (FT) Rheology

The nonlinear stress response under LAOS is represented in terms of intensities and phases of its Fourier harmonics as follows:

$$\sigma(t) = \sum_{n,\text{odd}} I_n \sin(n\omega t + \delta_n)$$

where I_n and δ_n are the *n*th-harmonic intensity and phase angle, respectively. Following this representation, other parameters such as Q $[Q = (I_3/I_1)/\gamma_o^2]$ which quantifies nonlinearity in system undergoing oscillatory shear deformation and its intrinsic value Q_o (defined as limiting value of Q as $\gamma_o \to 0$), are defined (Hyun & Wilhelm, 2008).

Stress Decomposition (SD) Technique

This technique decomposes the stress signal into separate elastic (σ') and viscous (σ'') based on symmetry (Cho et al., 2005).

The elastic and viscous responses are as follows:

$$\sigma'(\gamma) = \frac{\sigma(\gamma,\dot{\gamma}) - \sigma(-\gamma,\dot{\gamma})}{2}, \qquad \sigma''(\dot{\gamma}) = \frac{\sigma(\gamma,\dot{\gamma}) - \sigma(\gamma,-\dot{\gamma})}{2}$$

Analysis using this technique is usually performed alongside the use of Lissajous curves (Philippoff, 1966).

Chebyshev Parameters Approach

Similar to the Fourier series representation, the stress response is described using Chebyshev polynomials of the first kind, T_n (Ewoldt et al., 2008). As such:

$$\sigma'(x;\omega,\gamma_o) = \gamma_o \textstyle\sum_{n,\text{odd}} e_n(\omega,\gamma_o) T_n(x)$$

$$\sigma''(y;\omega,\gamma_o) = \dot{\gamma}_o \textstyle\sum_{n,\text{odd}} v_n(\omega,\gamma_o) T_n(y)$$

Where $x = \gamma/\gamma_o$ and $y = \dot{\gamma}/\dot{\gamma}_o$. The nth-order elastic and viscous contributions in this framework are represented by e_n and v_n respectively. Four other moduli for classifying intra-cycle nonlinear behavior linked to the Chebyshev approach are as follows:

$$G'_M = \frac{d\sigma}{d\gamma}\Big|_{\gamma=0} = \textstyle\sum_{n,\text{odd}} nG'_n = e_1 - 3e_3 + 5e_5 - \cdots$$

$$G'_{\mathrm{L}} = \frac{\sigma}{\gamma}\Big|_{\gamma=\pm\gamma_{\mathrm{o}}} = \sum_{n,\mathrm{odd}} G'_n(-1)^{(n-1)/2} = e_1 + e_3 + e_5 + \cdots$$

$$\eta'_{\mathrm{M}} = \frac{d\sigma}{d\dot{\gamma}}\Big|_{\dot{\gamma}=0} = \frac{1}{\omega}\sum_{n,\mathrm{odd}} G''_n(-1)^{(n-1)/2} = v_1 - 3v_3 + 5v_5 - \cdots$$

$$\eta'_{\mathrm{L}} = \frac{\sigma}{\dot{\gamma}}\Big|_{\dot{\gamma}=\pm\dot{\gamma}_{\mathrm{o}}} = \frac{1}{\omega}\sum_{n,\mathrm{odd}} G''_n = v_1 + v_3 + v_5 + \cdots$$

where local elastic measures, G'_{L} and G'_{M} are large-strain modulus and minimum-strain modulus, and local viscous measures η'_{L} and η'_{M} are the large-rate dynamic viscosity and minimum-rate dynamic viscosity respectively. Within the linear regime, elastic local measures G'_{L}, G'_{M} and G'_1 converge to the linear elastic modulus, G'. Similarly, viscous measures η'_{L}, η'_{M} and η'_1 $(= G''_1/\omega)$ converge to the linear viscosity, $\eta' = G''/\omega$. Furthermore, the strain hardening ratio (S) and shear thickening ratio (T) has been defined as follows:

$$S = \frac{G'_{\mathrm{L}} - G'_{\mathrm{M}}}{G'_{\mathrm{L}}}$$

$$T = \frac{\eta'_{\mathrm{L}} - \eta'_{\mathrm{M}}}{\eta'_{\mathrm{L}}}$$

Perfect Plastic Dissipation Ratio

A measure known as the plastic dissipation ratio (ϕ), which indicates the closeness of a LAOS response to that of an ideal yield stress fluid is given by $\phi = (\pi\gamma_{\mathrm{o}}G_1'')/(4\sigma_{\max})$ (Ewoldt et al., 2010).

Sequence of Physical Processes (SPP) Technique

To arrive at the relations that characterize the SPP technique, it is considered that the stress response under oscillatory shear traces a trajectory in an orthonormal basis formed by the strain [$\gamma(t)$], the frequency-normalized strain rate [$\dot{\gamma}(t)/\omega$], and the stress [$\sigma(t)$] (Rogers, 2017). For small strain amplitudes, this trajectory lies entirely within a plane, whereas deviations from the plane may be observed at larger strain amplitudes. Hence, in the SPP methodology, the stress response at any time during oscillation can be represented in terms of material functions as:

$$\sigma(t) = \gamma_{\mathrm{o}}[G_{\mathrm{t}}'(t)\sin\omega t + G_{\mathrm{t}}''(t)\cos\omega t + G_{\mathrm{t}}^{\mathrm{d}}(t)]$$

where G_{t}' represents the transient storage modulus, while G_{t}'' represents the transient loss modulus. The term $G_{\mathrm{t}}^{\mathrm{d}}$ accounts for the displacement stress at any time *t* during the oscillation. The advantage of this representation is that the transient moduli encountered in SPP—unlike previously defined moduli, which represent averaged values—can be obtained at any point in the oscillation cycle. The transient moduli can be expressed in terms of Fourier coefficients as follows:

$$\begin{aligned} G_{\mathrm{t}}'(t;\omega,\gamma_{\mathrm{o}}) = G_1' &+ \sum_{n=3,\mathrm{odd}} \left[-\frac{n(n-1)}{2} I_n \cos\big((n+1)\omega t + \delta_n\big) \right. \\ &\left. + \frac{n(n+1)}{2} I_n \cos\big((n-1)\omega t + \delta_n\big)\right] \end{aligned}$$

$$\begin{aligned} G_{\mathrm{t}}''(t;\omega,\gamma_{\mathrm{o}}) = G_1'' &+ \sum_{n=3,\mathrm{odd}} \left[-\frac{n(n-1)}{2} I_n \sin\big((n+1)\omega t + \delta_n\big) \right. \\ &\left. + \frac{n(n+1)}{2} I_n \sin\big((n-1)\omega t + \delta_n\big)\right] \end{aligned}$$

The temporal derivatives of the transient moduli can similarly be expressed in terms of the Fourier harmonics as follows:

$$\frac{dG_{\mathrm{t}}'}{dt} = \omega \sum_{n=3,\mathrm{odd}} \left[\frac{n(n-1)(n+1)}{2} I_n \sin\big((n+1)\omega t + \delta_n\big) - \frac{n(n-1)(n+1)}{2} I_n \sin\big((n-1)\omega t + \delta_n\big)\right]$$

$$\frac{dG_{\mathrm{t}}''}{dt} = \omega \sum_{n=3,\mathrm{odd}} \left[-\frac{n(n-1)(n+1)}{2} I_n \cos\big((n+1)\omega t + \delta_n\big) + \frac{n(n-1)(n+1)}{2} I_n \cos\big((n-1)\omega t + \delta_n\big)\right]$$

As in the case of LVE measures, a transient tan delta $\tan\delta_t = G_{\mathrm{t}}''/G_t'$ can also be obtained and used for viscoelastic characterization.

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