



DDDPlus™

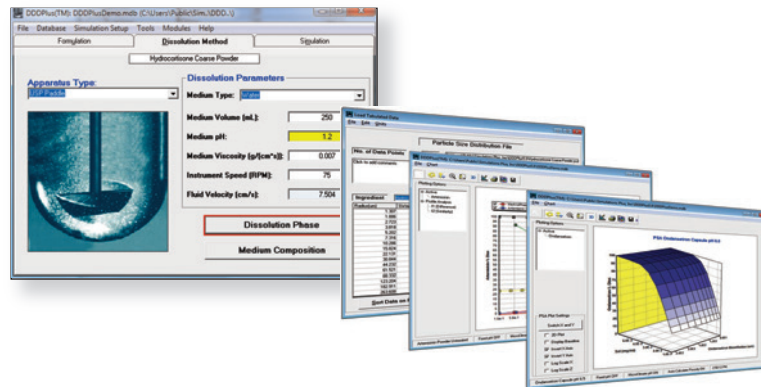
in vitro dissolution testing... reimagined!

New in version 5.0!

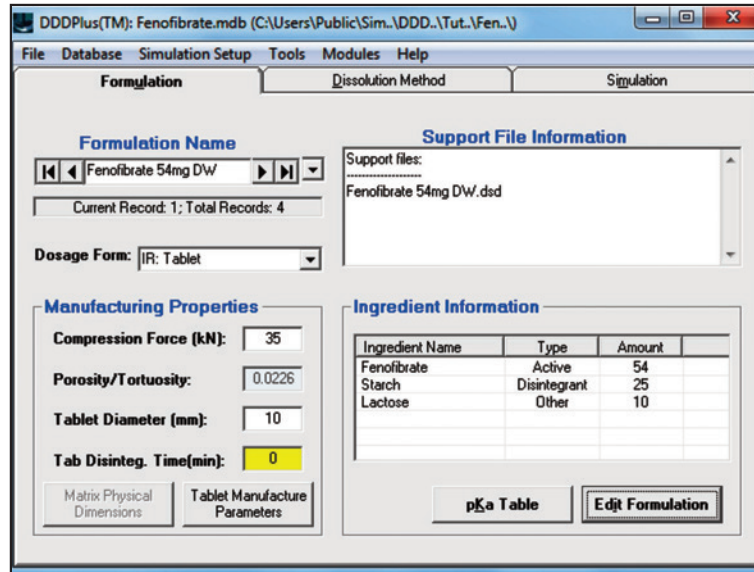
- Additional dosage forms: new models for coated beads, bilayer tablets, and delayed release coated tablets
- Integration of the ADMET Predictor™ Module: now predict key physicochemical properties from chemical structure
- Improved handling of bile salt effects on solubility in the biorelevant media
- Upgraded 3D Parameter Sensitivity Analysis: assess the impact of changes to any combination of formulation & experimental parameters together
- Various options for defining manufacturing properties: tensile strength and bonding constants can be added to predict disintegration
- ... and more!

Utilize modeling and simulation to...

- Integrate with GastroPlus™ absorption/PBPK models to optimize formulations and generate mechanistic IIVCs – better extrapolation of dissolution inputs for PBPK models
- Assist with dissolution method development
- Assess various formulation strategies to achieve a target *in vitro* dissolution profile
- Apply virtual 'lot-to-lot' variability effects to help establish dissolution specifications – remove the 'guesswork' associated with the identification of dissolution variability and its impact on PK exposure



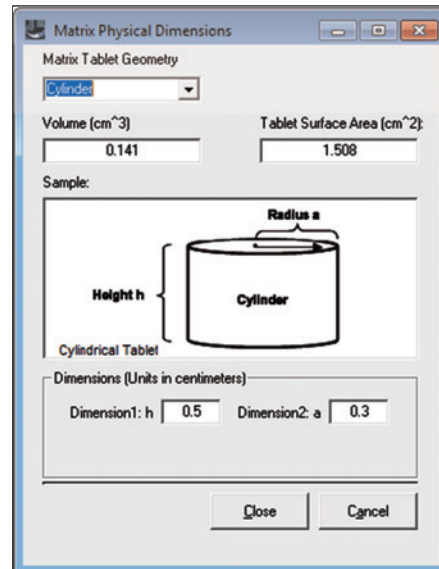
DDDPlus™. . . The industry's only *in vitro* dissolution software for formulation and analytical scientists.



DDDPlus (Dose Disintegration and Dissolution Plus) is an advanced computer program for formulation scientists to simulate the *in vitro* disintegration and dissolution of active pharmaceutical ingredients (API) and excipients under various experimental conditions. For new API, a single calibration experiment is all that is needed, after which DDDPlus will predict how changes in formulation or experimental parameters will affect the dissolution rate. With DDDPlus, you no longer have to rely on 'cut and try' methods to finalize a formulation design.

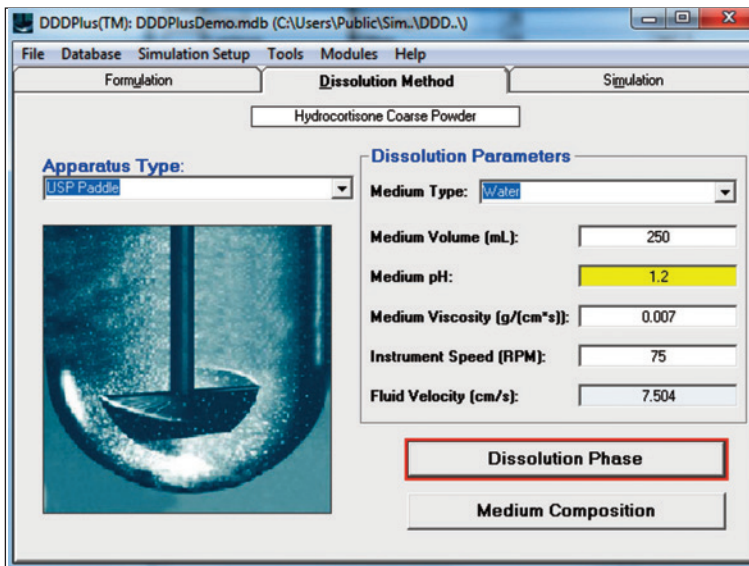
DDDPlus models the following dosage forms:

- Powders
- Capsules
- Tablets
- Polymer Matrix (Swellable & Non-Swellable)
- **NEW!** Coated beads
- **NEW!** Bilayer tablets
- **NEW!** Delayed release coated tablets



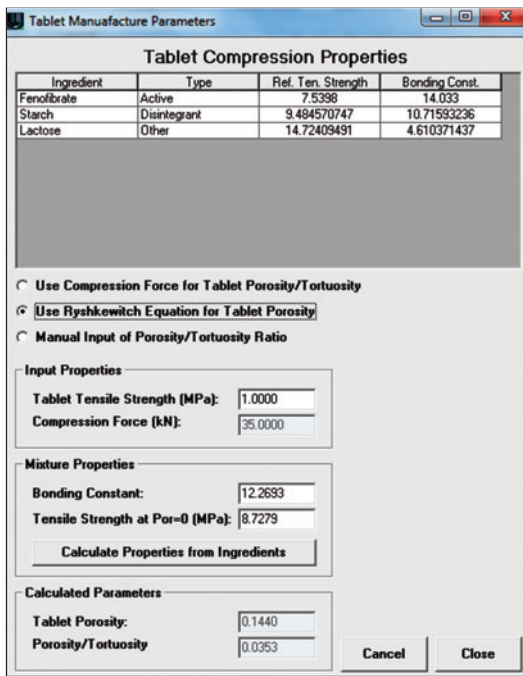
4 USP experimental apparatus are defined, with estimates of fluid velocity and hydrodynamic effects for each:

- USP Paddle
- USP Basket
- USP Flow Thru
[closed and open loop options]
- Rotating Disk
- **NEW!** Pion μ Diss Profiler™



DDDPlus allows you to select from one of 5 mathematical models to describe the dissolution of any ingredients included in the formulation. The mathematical models for the in vitro dissolution simulation account for the effects of:

- Manufacturing properties for the product (e.g., compression force, tensile strength, mean disintegration times)



- Physicochemical properties of the formulation ingredients under study: pKa's, aqueous solubility vs. pH, biorelevant solubility, diffusion coefficient, logP, and density
- Particle size distributions for each of the formulation ingredients
- Interactions between the active ingredient and formulation excipients [e.g., solubilizers, disintegrants, wetting agents]
- Microclimate pH-dependence of solubility and dissolution/precipitation
- Basic hydrodynamic effects, including different flow patterns and fluid velocities, for each experimental apparatus
- Micelle-facilitated dissolution through the incorporation of surfactants in the media
- ... and more!

Formulation Composition

File Structure Import Tools

Selection and Preview Grid

Ingredient Name	Ingredient Type	Amount (mg)	MWt (g/mol)	Diff. Coeff. (cm ² /s)	Density (g/ml)
Hydrocortisone	Active	150	362.47	0.587	1.27
Starch	Disintegrant	25	333.55	0.432	1.58
Lactose	Other	10	342.3	0.77	1.58

Physicochemical Information

Ingredient Name	Ingredient Type	Mol. Weight (g/mol)
Hydrocortisone	Active	362.47
Ref. Solubility (mg/ml)	pH for Ref. Solubility	
0.361	7.2	
Density (g/ml)	Precip. Time (sec)	Diff. Coeff. (cm ² /s*10 ⁻⁵)
1.27	900	0.587
LogP	@ pH	
1.58	-1	

Biorelevant Solubility **Surfactant Solubility**

Chemical Structure: O=C1CC[C@H]2[C@@H]3[C@H]([C@@H]1CC[C@@H]2O)C(=O)O

Formulation Specific Information

Amount (mg)	Salt Type	No. Moles
150	None	1

Particle Size Distribution...

Mean Radius (um)	Stan. Dev.	Num. of Bins
17.94	2.4	16

Distribution Type: Log Normal (Geometric Inputs) Rmin: 1.298 Rmax: 248.003

Constants

Calibration Constant
1

Dissolution Model: Mass Transfer

Buttons: Add Ingredient, Delete Ingredient, Import Excipients, Close

- In early stage development, sufficient amounts of compound are not available for repeated conventional testing. What would be the expected dissolution profile for an initial formulation?
- You make your first formulation for a new compound, and dissolution is too slow. What formulation parameters can you change to make it acceptable?
- You're asked to develop a formulation for a low solubility compound. You run one experiment with powder that does not dissolve fast enough. What can be done to produce the desired dissolution rate – micronization, solubilizer, wetting agent, or some combination?
- A dissolution experiment produces unexpected results. You suspect human error, but what best explains the data (buffer composition, instrument speed, fluid volume, etc.)?
- You need to develop a dissolution experiment that mimics a deconvoluted *in vivo* release profile. What experimental conditions are needed to generate a meaningful IVIVC/R (instrument type, fluid volume, instrument speed, buffer composition, etc.)?
- As you scale up manufacturing, you identify a certain level of variability in key formulation properties (e.g., dose, excipient content). How much 'lot-to-lot' variability are you allowed before you begin falling outside the established dissolution specifications? And, how would these simulated dissolution profiles be translated to changes with the *in vivo* pharmacokinetics (PK)?

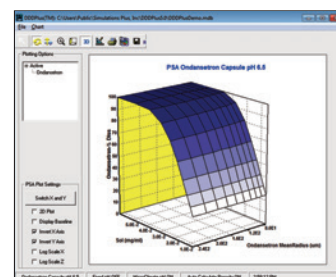
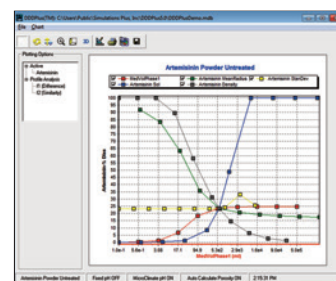
Find answers to these questions and more with DDDPlus!

Simulation Modes

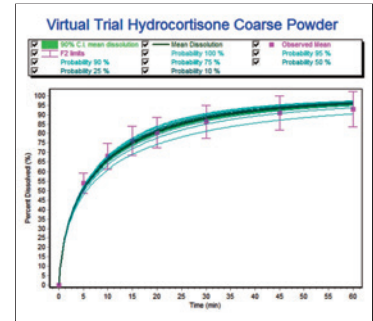
Single Simulation: based on compound properties (whether measured or predicted through the ADMET Predictor Module), formulation information, and *in vitro* dissolution setup, easily run a simulation to predict the time course changes in amount (or percent) dissolved for any ingredient in the product. Also track changes in microclimate and bulk pH levels vs. time.

Parameter Sensitivity Analysis (PSA): select any formulation or experimental parameters to assess the impact of changes on the *in vitro* dissolution vs. time profiles

NEW! 3D PSA – now analyze the impact of changes in a 'design space' by simulating all combinations of any two selected parameters. Quickly identify an optimal combination that achieves the desired dissolution result



Virtual Trials: run a series of simulations for different dissolution experiments, each of which is described by a random sample of formulation and/or experimental parameters, to imitate the variances expected with actual formulation or experimental setups. This powerful capability allows you to assess the combined effects of variations in formulation or experimental variables on the *in vitro* dissolution profiles, helping to establish dissolution specifications as you scale up manufacturing. And, when coupled with GastroPlus models, you can begin to translate the dissolution 'variability' to expected changes in pharmacokinetic profiles and assess virtual bioequivalence between formulation lots.



Optimization Module: calibrate your DDDPlus dissolution model using experimental *in vitro* dissolution vs. time data. Fit any combination of parameters to build your baseline model – once built and validated with existing data, use it to explore changes in formulation, experiment and more.

Difference Factor 'f1' and Similarity Factor 'f2':

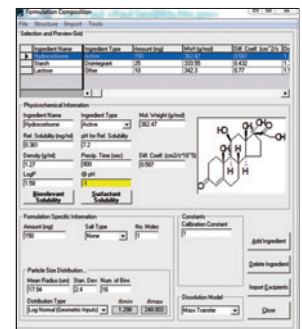
The Difference Factor 'f1' and Similarity Factor 'f2' are recommended for dissolution profile comparisons in the FDA guidance for the industry. Once you run a simulation, you can load a reference profile and use the Difference Factor and Similarity Factor tools in DDDPlus to automatically run simulations across all formulation records and calculate the 'f1' and 'f2' values.



Model Inputs

Physicochemical Parameters

With DDDPlus, you can add as many excipients to the formulation as you like. This is done through the Formulation Composition window shown below.

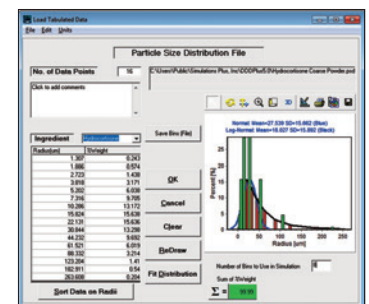


NEW! ADMET Predictor Module: using the industry's #1-ranked Quantitative Structure-Activity Relationship (QSAR) models from our ADMET Predictor program, import chemical structures (as SMILES strings or .mol/.sdf formats) to predict the physicochemical properties required for the DDDPlus. This can provide a quick, reliable foundation for your modeling activities.

NEW! DDDPlus now allows you to enter multiple ingredients of the same type: define multiple excipients in the formulation. Any excipients can be entered, or you can use the database of commonly used excipients, provided with the program, where all necessary physicochemical properties are defined!

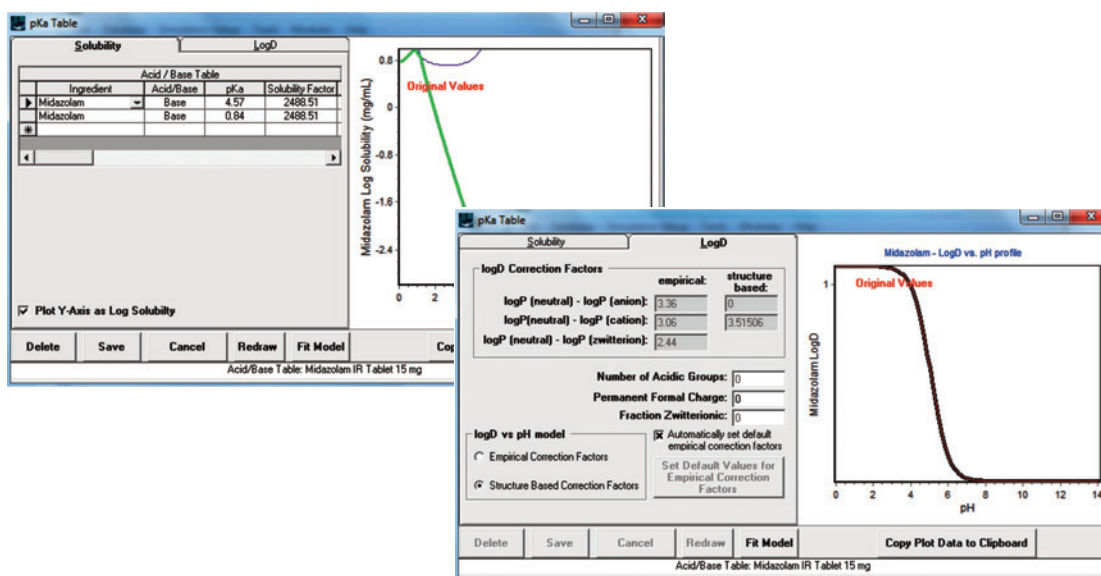
Excipient Name	Type	MW	Solubility	Ref. g/L	DfL	Coef.	Density	Molecular Weight	Ref. Ten. Strength	Binding Const.
Adipic acid	Other	148.14	0	3.98	1.32	0	1.23	0	23.7399 N/P	6.716586207
Dibutyl sebacate	Other	422.59	0.00056	5.9	0.99	1.2	0	0	23.7399 N/P	6.716586207
Lactose	Other	342.3	0	5.495	0.77	1.51	0	0	23.7399 N/P	6.716586207
Mannitol	Other	182.17	180.8	7	1.56	1.5	0	2.57624075	11.99665793	6.716586207
Phenol	Other	111.14	180	7	1.33	1.2	0	0	23.7399 N/P	6.716586207
Propylene glycol	Solubility	76.09	480	7	1.56	1.25	0	0	23.7399 N/P	6.716586207
SLC	Watering agent	288.4	180	7	0.75	1.2	0	0	23.7399 N/P	6.716586207
Starch	Other	162.16	2000	7	1.56	1.48	0	0	23.7399 N/P	6.716586207
Sorbitol	Disintegrant	332.05	0.1	6.8	0.42	1.25	0	1.48463042	10.7193226	6.716586207
Succinic acid	Other	118.09	9.5	5.6	0.67	0	0	0	23.7399 N/P	6.716586207
Talcum	Other	342.3	100	7	0.77	1.58	0	0	23.7399 N/P	6.716586207
Triethyl Citric Acid	Other	150.05	1300	7	0.38	1.76	0	0	23.7399 N/P	6.716586207
HPMC	Solubility	100.0	100	7	1.11	1.2	0	0	23.7399 N/P	6.716586207
Disintegrant	Other	180.16	204	7	1.99	1.64	0	0	23.7399 N/P	6.716586207
Calcium Carbonate	Disintegrant	100.087	0.847	8.27	1.39	2.8	0	0	23.7399 N/P	6.716586207
HPMC K100	Polymer	90000	0.5	7.2	0.00055	1.32	476.5	13.46	8.8	6.716586207
HPMC E5000	Polymer	200000	0.5	7.2	0.00055	1.32	476.5	13.46	8.8	6.716586207
Magnesium Stearate	Other	581.27	0.03	7	0.66	1.2	0	0	23.7399 N/P	6.716586207

You can either input mean radius and standard deviation for the particle size distribution or load your own sieve distribution data (fractional or cumulative). DDDPlus comes with a tool to easily convert your cumulative particle size distribution data (e.g., D(10), D(50), D(90)) into a full normal or log-normal distribution function.



Model Inputs

With DDDPlus, you can enter multiple pKa ionization constants for each ingredient. This information is used to define the aqueous solubility vs. pH profile and in the calculation of media pH during the simulation. Plus, the theoretical logD vs. pH profile is generated, which can be applied to estimate the bile salt solubilization effect



Experimental Setup

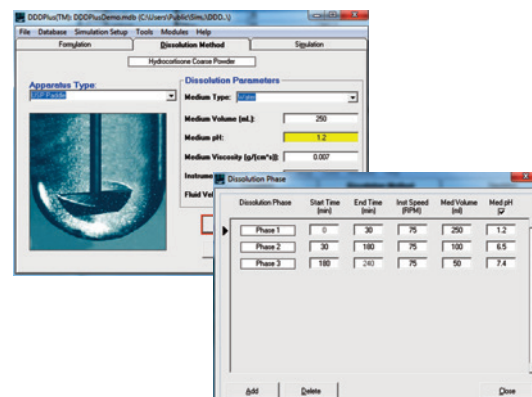
Dissolution Method Conditions and Multi-Phase Experiments

With DDDPlus, you can define your dissolution method conditions like apparatus, instrument speed, medium volume and medium type. DDDPlus calculates the fluid velocity automatically based on the instrument speed and apparatus type and utilizes this information to capture basic hydrodynamic effects on the dissolution rate.

You can add as many experimental phases as you want to better mimic the *in vivo* environment. This can be helpful when trying to design an *in vitro* dissolution method to achieve a meaningful *in vitro-in vivo* correlation (IVIVC).

Dissolution Media and Microclimate pH

DDDPlus has a sophisticated pH engine to calculate the dissolution media pH and solubility of each ingredient at the surface and bulk pHs. You can select from more than 90 built-in buffers, including all USP and biorelevant recipes, or easily design your own. You can also vary the concentrations of the different ingredients to create custom buffers at various pH.

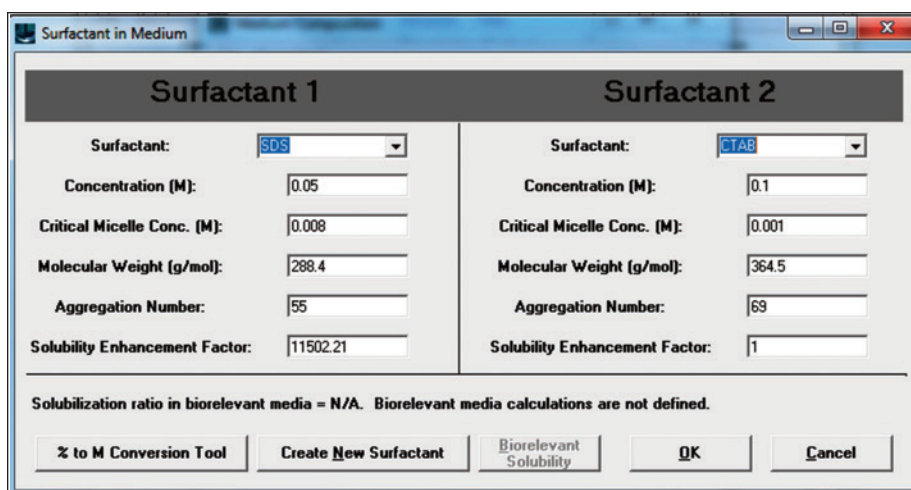


Microclimate pH

DDDPlus dynamically calculates the microclimate pH (pH at the diffusion layer of the particle) for each ingredient in the formulation. You can select either “microclimate pH” to calculate the solubility of the ingredient at the diffusion layer or “bulk pH” for solubility in the dissolution media. The “bulk pH” is utilized to capture any potential precipitation effects once the dissolved material reaches the bulk environment.

Surfactants

DDDPlus allows you to add up to 2 surfactants per dissolution media. You have the option to choose from a list of several common surfactants or create your own.



NEW! Surfactant solubility tool: easily calculate the CMC and/or surfactant enhancement factor provided you have selected a media with one or two surfactants. This applies to non-biorelevant surfactants like SDS, CTAB, BRIJ, CHAPS, etc.

