



## **EFLUXX-ID<sup>®</sup> Green Multidrug Resistance Assay Kit**

Catalog #: ENZ-51029-K100

for flow cytometry  
for 100 assays

## **USE FOR RESEARCH PURPOSES ONLY**

Unless otherwise specified expressly on the packaging, all products sold hereunder are intended for and may be used for research purposes only and may not be used for food, drug, cosmetic or household use or for the diagnosis or treatment of human beings. Purchase does not include any right or license to use, develop or otherwise exploit these products commercially. Any commercial use, development or exploitation of these products or development using these products without the express written authorization of Enzo Life Sciences, Inc. is strictly prohibited. Buyer assumes all risk and liability for the use and/or results obtained by the use of the products covered by this invoice whether used singularly or in combination with other products.

## **LIMITED WARRANTY; DISCLAIMER OF WARRANTIES**

These products are offered under a limited warranty. The products are guaranteed to meet all appropriate specifications described in the package insert at the time of shipment. Enzo Life Sciences' sole obligation is to replace the product to the extent of the purchasing price. All claims must be made to Enzo Life Sciences, Inc., within five (5) days of receipt of order. THIS WARRANTY IS EXPRESSLY IN LIEU OF ANY OTHER WARRANTIES OR LIABILITIES, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON- INFRINGEMENT OF THE PATENT OR OTHER INTELLECTUAL PROPERTY RIGHTS OF OTHERS, AND ALL SUCH WARRANTIES (AND ANY OTHER WARRANTIES IMPLIED BY LAW) ARE EXPRESSLY DISCLAIMED.

## **TRADEMARKS AND PATENTS**

Several Enzo Life Sciences products and product applications are covered by US and foreign patents and patents pending. Enzo is a trademark of Enzo Life Sciences, Inc.

**FOR RESEARCH USE ONLY.  
NOT FOR USE IN DIAGNOSTIC PROCEDURES.**



Please read entire booklet before proceeding with the assay.



Carefully note the handling and storage conditions of each kit component.



Please contact Enzo Life Sciences Technical Support if necessary.

## TABLE OF CONTENTS

I.	Introduction.....	2
II.	Materials Supplied & Storage .....	3
III.	Other Materials Needed.....	3
IV.	Safety Warnings and Precautions.....	4
V.	Methods and Procedures.....	5
	A. Reagent Preparation .....	5
	B. Assay Protocol .....	6
	C. Flow Cytometry Measurement of Samples.....	8
VI.	Calculation of Results .....	10
VII.	Appendices.....	11
	A. Spectral Characteristics of EFLUXX-ID® Green	
	Detection Reagent .....	11
	B. Technical Hints .....	11
	C. Results.....	12
VIII.	References .....	14
IX.	Troubleshooting Guide .....	16
	Contact Information .....	18

## I. INTRODUCTION

Multidrug resistance relates to resistance of tumor cells to a whole range of chemotherapy drugs with different structures and cellular targets. The phenomenon of multidrug resistance (MDR) is a well-known problem in oncology and thus needs profound consideration in cancer treatment. One of the underlying molecular rationales for MDR is the up-regulation of a family of transmembrane ATP binding cassette (ABC) transporter proteins that present in practically all living organisms. These proteins cause chemotherapy resistance in cancer by actively extruding a wide variety of therapeutic compounds from the malignant cells. The same ABC transporters play an important protective function against toxic compounds in a variety of cells and tissues and at blood-tissue barriers.

Enzo Life Sciences' EFLUXX-ID<sup>®</sup> Green Multidrug Resistance Assay Kit is designed for functional detection and profiling of multidrug resistant phenotypes in live cells (both suspension and adherent). The kit provides a fast, sensitive and quantitative method for monitoring the function and expression of the three clinically most important multidrug resistance proteins: MDR1 (P-glycoprotein), MRP1/2 and BCRP. The kit includes EFLUXX-ID<sup>®</sup> Green Detection Reagent as a major component. Being a substrate for three main ABC transporter proteins, this reagent serves as an indicator of these proteins' activity in the cell. The proprietary AM-ester form of the EFLUXX-ID<sup>®</sup> Green Detection Reagent is a hydrophobic non-fluorescent compound that readily penetrates the cell membrane and is subsequently hydrolyzed inside of the cells by intracellular esterases. Unless the EFLUXX-ID<sup>®</sup> is pumped out of the cell, the esterase cleaved dye is trapped inside the cell. The fluorescence signal of the dye generated within the cells thus depends upon the activity of the ABC transporters. The cells with highly active transporters will demonstrate lower fluorescence because of the active efflux of the reagent from the cell. Application of specific inhibitors of the various ABC transporter proteins, included in the kit, allows differentiation between the three common types of pumps. The activity of a particular MDR transporter is defined by the difference between the amount of the dye accumulated in the presence and in the absence of the inhibitors, respectively.

The flow cytometry assay is based on determining fluorescence intensities of the tested cells after a short in vitro incubation of cell suspension with the EFLUXX-ID® Green Detection Reagent in the presence or absence of specific ABC transporter inhibitors. The results of the test can be quantified by calculating the MDR activity factor (MAF) values, which allow comparison of multidrug resistance between different samples or cell lines.

## II. MATERIALS SUPPLIED & STORAGE



Avoid repeated freeze/ thaw cycles.

All reagents are shipped on dry ice. Upon receipt, the kit should be stored upright and protected from light at  $\leq -20^{\circ}\text{C}$ . When stored properly, these reagents are stable for one year upon receipt. **Avoid repeated freezing and thawing.**

Reagents provided in the kit are sufficient for 100 flow cytometry assays using live cells (adherent or in suspension).

Reagent	Quantity
EFLUXX-ID® Green Detection Reagent	1 vial
MDR1 Inhibitor (Verapamil)	300 nmoles
MRP Inhibitor (MK-571)	750 nmoles
BCRP Inhibitor (Novobiocin)	1.5 $\mu\text{moles}$
Propidium Iodide	500 $\mu\text{L}$

## III. OTHER MATERIALS NEEDED

1.  $\text{CO}_2$  incubator ( $37^{\circ}\text{C}$ ), tissue culture plasticware
2. Water bath or thermostated dry block for  $37^{\circ}\text{C}$  incubations
3. Standard flow cytometer equipped with a blue laser (488nm)
4. Calibrated, adjustable precision pipettors, preferably with disposable plastic tips
5. 5 mL round bottom polystyrene tubes for holding cells during staining and assay procedure
6. Adjustable speed centrifuge with swinging buckets
7. Anhydrous DMSO
8. Complete growth medium without Phenol Red (e.g., Dulbecco's Modified Eagle medium, D-MEM)
9. PBS (optional, for washing procedures)

#### IV. SAFETY WARNINGS & PRECAUTIONS

##### FOR RESEARCH USE ONLY. NOT FOR USE IN DIAGNOSTIC PROCEDURES.



Handle  
with care

- Some components of this kit may contain hazardous substances. Reagents can be harmful if ingested or absorbed through the skin and may cause irritation to the eyes. They should be treated as possible mutagens, should be handled with care and disposed of properly.
- **Observe good laboratory practices. Gloves, lab coat, and protective eyewear should always be worn. Never pipet by mouth. Do not eat, drink or smoke in the laboratory areas. All blood components and biological materials should be treated as potentially hazardous and handled as such. They should be disposed of in accordance with established safety procedures.**
- **To avoid photobleaching, perform all manipulations in low light environments or protected from light by other means. Some components of this kit may contain hazardous substances. Reagents can be harmful if ingested or absorbed through the skin and may cause irritation to the eyes. They should be treated as possible mutagens, should be handled with care and disposed of properly.**



Protect  
from light

## V. METHODS AND PROCEDURES

**NOTE:** PLEASE READ THE ENTIRE PROCEDURE BEFORE STARTING. Allow all reagents to thaw at room temperature before starting with the procedures. Upon thawing, gently hand-mix or vortex the reagents prior to use to ensure a homogenous solution. Briefly centrifuge the vials at the time of first use, as well as for all subsequent uses, to gather the contents at the bottom of the tube.

### A. Reagent Preparation

#### 1. EFLUXX-ID® Green Dye Stock Solution

Resuspend the EFLUXX-ID® Green Detection Reagent in 300  $\mu$ L anhydrous DMSO. Vortex gently or slowly rotate the tube to dissolve. Store the solution at -20°C. The reconstituted reagent is stable for at least 6 months when stored as recommended.

#### 2. 5 mM Verapamil (MDR1 Inhibitor)

Resuspend the MDR1 Inhibitor (Verapamil) in 60  $\mu$ L anhydrous DMSO. Vortex gently or slowly rotate the tube to dissolve. Store the solution at -20°C. The reconstituted reagent is stable for at least 6 months when stored as recommended.

#### 3. 10 mM MK-571 (MRP Inhibitor)

Resuspend the MRP Inhibitor (MK-571) in 75  $\mu$ L anhydrous DMSO. Vortex gently or slowly rotate the tube to dissolve. Store the solution at -20°C. The reconstituted reagent is stable for at least 6 months when stored as recommended.

#### 4. 50mM Novobiocin (BCRP Inhibitor)

Resuspend the BCRP Inhibitor (Novobiocin) in 30  $\mu$ L anhydrous DMSO. Vortex gently or slowly rotate the tube to dissolve. Store the solution at -20°C. The reconstituted reagent is stable for 6 months when stored as recommended.

## B. Assay Protocol

Cells should be maintained via standard tissue culture practices. Always make sure that cells are healthy and in the log phase of growth before using them for an experiment.

**IMPORTANT:** *Because membrane transport mediated by ABC transporters is a complex process that is highly dependent on physiological conditions of cell populations and intracellular ATP status it is important to use living cells in good condition. ATP depletion will decrease the activity of the membrane transporters.*

1. Grow cell line of choice in the appropriate medium. Select drugs may interfere with dye efflux. Therefore, the cells should be kept in drug-free medium for at least one week. Anti-microbial agent may be included in the medium, since they do not interfere with multi-drug resistance proteins. Medium should be replaced one day before the assay. Adherent cells should be dislodged from the plates using standard methods and used in suspension for the assay.
2. Count cells using a hemacytometer. For one sample test, four assays should be performed in triplicates (with three different inhibitors and without inhibitor). Approximately  $2-5 \times 10^5$  cells are required for each assay. Prepare a cell suspension containing  $1-2 \times 10^6$  cells/mL in pre-warmed ( $37^\circ\text{C}$ ) complete indicator-free medium.
3. For each sample to be assayed, prepare four sets of tubes (in triplicate). Include one tube for the unstained cell control.
4. Immediately prior to use, prepare intermediate dilutions of all 3 inhibitors by mixing appropriate volumes of inhibitor stock solutions (from step V-A2, A3 and A4) and pre-warmed ( $37^\circ\text{C}$ ) complete indicator-free medium using the volumes specified in the following table.

**IMPORTANT:** *Prepare the dilutions of the inhibitors immediately prior to use as they are susceptible to hydrolysis in aqueous solution.*



Table 1. Dilution of Inhibitors		
Inhibitor	Vol. Inhibitor/Conc'n	Vol. Medium
MDR1 Inhibitor	16 $\mu$ L, 5 mM	1 mL
MRP Inhibitor	20 $\mu$ L, 10 mM	1 mL
BCRP Inhibitor	8 $\mu$ L, 50 mM	1 mL

5. Add 125  $\mu$ L of inhibitor into separate tubes as indicated in the following table. For control, add 125  $\mu$ L pre-warmed (37°C) complete indicator-free medium containing 5% DMSO.

Table 2. Assay Reagent Volumes			
Tube Nos.	Vol. Dilute Inhibitor (from step B-4)	Vol. Cell Suspension	Vol. Dilute EFLUXX-ID® Green Dye
1-3	125 $\mu$ L MDR1 Inhibitor	250 $\mu$ L	125 $\mu$ L
4-6	125 $\mu$ L MRP Inhibitor	250 $\mu$ L	125 $\mu$ L
7-9	125 $\mu$ L BCRP Inhibitor	250 $\mu$ L	125 $\mu$ L
10-12 (Stained Controls)	125 $\mu$ L Medium/DMSO	250 $\mu$ L	125 $\mu$ L
13 (Unstained Control)	250 $\mu$ L Medium/DMSO	250 $\mu$ L	—

6. Add 250  $\mu$ L of cell suspension into each tube (see **Table 2**). Gently mix the contents of each tube by pipetting (avoid introducing bubbles) and incubate all the tubes at 37°C for 5 min.
7. Dilute the EFLUXX-ID® Green dye stock solution (from step V-A1) by combining 40  $\mu$ L of the stock solution and 2 mL of pre-warmed (37°C), complete indicator-free medium. Mix well by vortexing the tube gently.

**IMPORTANT:** Dilution of the EFLUXX-ID® Green dye stock solution should be done just prior to use as it is susceptible to hydrolysis in aqueous solution.

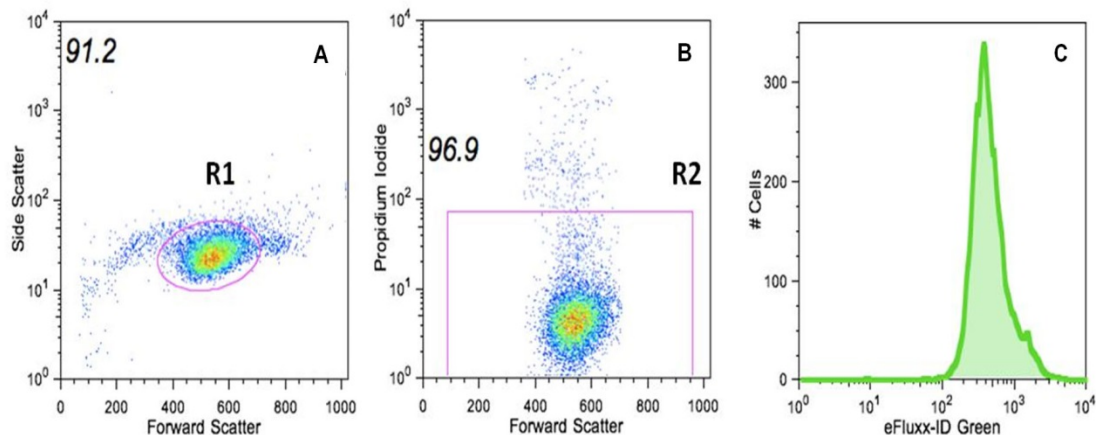
8. Begin the assay by adding 125  $\mu$ L of the freshly diluted EFLUXX-ID® Green dye solution (from step B-7) into each tube (except the tube labeled for unstained cells). Gently mix cell suspensions by pipetting (avoid introducing bubbles) and incubate all the tubes at 37°C for 30 min.
9. After 25 min of incubation, 5  $\mu$ L of the provided stock solution of Propidium Iodide can be added to each tube for cell viability monitoring.
10. Perform flow cytometry measurements immediately after reaction (proceed to the part C).
11. If immediate measurements are not possible, or if the number of samples is over 30, stop the reaction by rapid centrifugation (200xg, 1 min.). Discard the supernatant and re-suspend the cells in 0.5 mL of ice cold complete indicator-free medium or PBS containing dilute Propidium Iodide (50  $\mu$ L of the provided stock solution of Propidium Iodide in 5 mL of medium or PBS). These samples can be stored at 4°C for several hours.

## C. Flow Cytometry Measurement of Samples

The cellular green fluorescence signal of EFLUXX-ID® Green Detection Reagent should be measured using a flow cytometer in all tubes in the living (Propidium Iodide (PI) negative) cell population with identical equipment settings.

1. Within the flow cytometry software, set an FSC-SSC dot plot, an FSC-FL3 dot plot, and an FL1 histogram plot. For better separation of the different cell populations, using a log scale is recommended for the fluorescence channels (FL1 and FL3).
2. Run unstained cells and adjust both forward and side scatter PMT amplifications to display all the cell subsets on the FSC-SSC dot plot.
3. Set a gate (R1) on the FSC-SSC dot plot, selecting the cell population of interest but excluding cell debris (Figure 1A). Display the cells selected by the R1 gate in an FSC-FL3 dot plot format.

4. Set a second gate (R2) in the FSC-FL3 window to exclude PI-positive cells from analysis (Figure 1B). To avoid errors originated from the spillover of green fluorescence of the EFLUXX-ID® Green Detection Reagent, set the R2 border as high as possible. Display R2-gated events in the FL1 histogram plot format.
5. Run tube no. 1 and adjust the PMT amplification for FL1 so that the peak of the histogram is located between the second and third decades on the FL1 histogram channel (Figure 1C).
6. Save settings in a properly designated template file (e.g. “MDR settings”). We recommend the use of the same or similar settings whenever possible. You may need to readjust slightly the PMT amplifications and /or the gate locations after an initial test run.



**Figure 1.** Flow cytometry measurements of the samples. Setting the parameters: Gate out the debris (Panel A), gate PI-negative events (Panel B), and set PMTs for the FL1 fluorescence channel (Panel C)

## VI. CALCULATION OF RESULTS

Calculate the mean fluorescence intensity (MFI) values for each triplicate set of measurements:

FMDR1 from tubes no. 1, 2 and 3

FMRP from tubes no. 4, 5 and 6

FBCRP from tubes no. 7, 8 and 9

F0 from tubes no. 10, 11 and 12

If differences between parallel sets of measurements are <10%, use all three values to calculate the mean. If one value is extreme (a difference of >10%), disregard the unreliable data, and calculate the mean from the other two. If all MFI values differ by >10%, redo the analysis (see the troubleshooting guide).

Calculate the multidrug resistance activity factor (MAF) for each transporter, using the following formulas:

$$\text{MAFMDR1} = 100 \times (\text{FMDR1} - \text{F0})/\text{FMDR1}$$

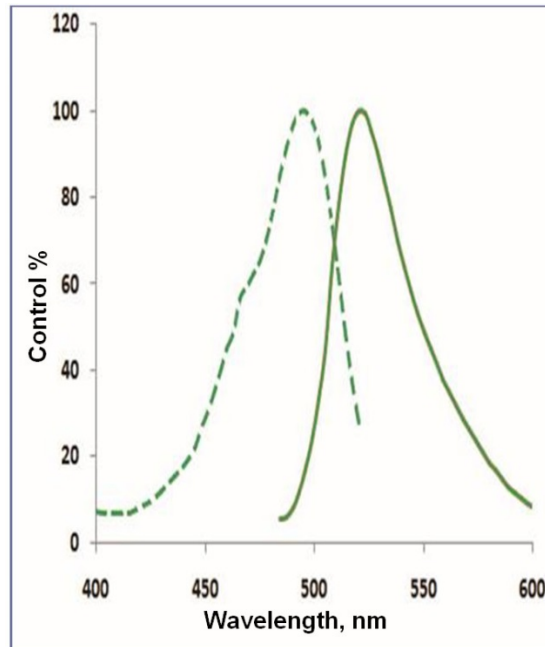
$$\text{MAFMRP} = 100 \times (\text{FMRP} - \text{F0})/\text{FMRP}$$

$$\text{MAFBCRP} = 100 \times (\text{FBCRP} - \text{F0})/\text{FBCRP}$$

In extreme cases (without MDR1, MRP or BCRP activity), the MFI values corresponding to inhibitor-treated cells can be smaller than the MFI value of non-inhibitor-treated cells. In such cases, corresponding MAF values should be regarded as zero.

## VII. APPENDICES

### A. Spectral Characteristics of EFLUXX-ID® Green Detection Reagent



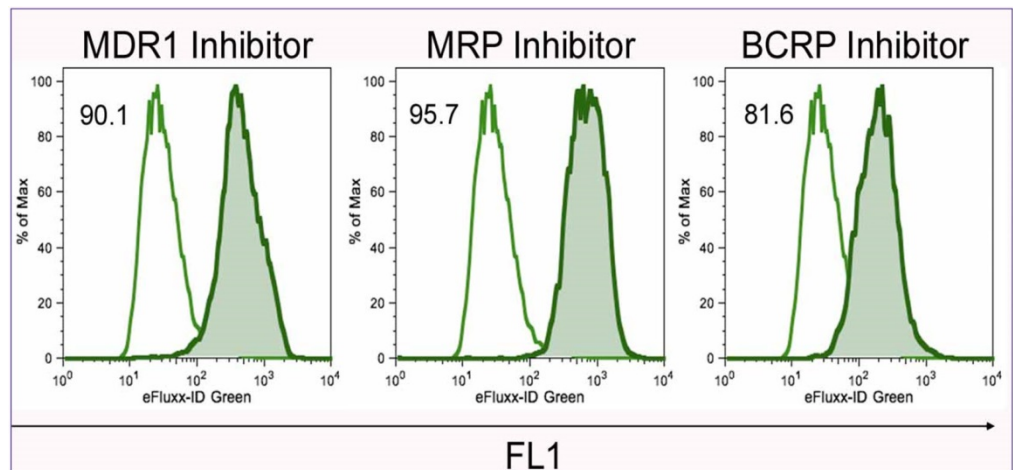
**Figure 2.** The absorption and emission peaks of EFLUXX-ID® Green detection dye are 490nm and 514nm, respectively. It can be well excited with an argon ion laser at 488nm, and detected in the FL1 channel of most bench flow cytometers.

### B. Technical Hints

1. Multidrug resistance assay is a functional test that requires living cells in good condition. The cells should always be kept in the appropriate incubation buffer, containing all the essential components. Do not use fixatives, azide or other preservatives.
2. Shear stress can be harmful to the cells. Do not vortex cell suspensions. Always mix them with gentle pipetting. Avoid forming excessive bubbles.
3. Cells in suspension sediment very rapidly and have to be mixed prior to any procedure (counting, aliquotting, running the samples on a flow cytometer). Mix cells by gentle pipetting and forming excessive bubbles.
4. Cell suspensions at the recommended concentrations will normally result in 100-300 events/sec flow rate. Keeping the flow rate below 600 events/sec is recommended.

## C. Results

1. The theoretical range of the MAF values are between 0 and 100. Studies comparing MAF values with clinical response to a chemotherapeutic treatment suggest that a specimen with an MAF value of <20 can be regarded as multidrug resistance negative, while MAF values >25 are indicative of multidrug resistance positive specimens.
2. In drug-selected cell lines exhibiting extremely high expression levels of ABC transporter proteins, the MAF values can be as high as 95-98.
3. Typical results of the assay are presented in **Figure 3**.



**Figure 3.** Typical results of the multidrug resistance assay. CHO K1 cells were incubated with EFLUXX-ID® Green Detection Reagent with and without specific inhibitors according to the kit protocol. Resulting fluorescence was measured using flow cytometry. Tinted histograms show fluorescence of inhibitor-treated samples and non-tinted histograms show fluorescence of untreated cells. The difference in fluorescence is indicative of a corresponding protein activity. The numbers in the upper left corners are MAF scores (multidrug resistance activity factors)—quantitative characteristics of multidrug resistance.

4. The EFLUXX-ID® Green Multidrug Resistance Assay Kit has been validated in various cell lines expressing multidrug resistance proteins that are summarized in **Table 3**.

<b>Cell Line (Reference)</b>	<b>MDR1</b>	<b>MRP</b>	<b>BCRP</b>
CHO K1 (6)	+	+	+
HeLa (6)	-	-	-
A549 (7)	-	+	+
HCT-8 (8, 9)	+	+	-
Hep-G2 (10)	+	-	-
Jurkat (11)	-	+	-
U-2 OS (12)	+	+	+
U-2 OS RFP (12)	+	+	+



## VIII. REFERENCES

1. Homolya L, Hollo Z, Germann UA, Pastan I, Gottesman MM and Sarkadi B. (1993) Fluorescent cellular indicators are extruded by the multidrug resistance protein. *J Biol Chem* **268**: 21493-21496.
2. Feller N, Kuiper CM, Lankelma J, Ruhdal JK, Scheper RJ, Pinedo HM, Broxterman HJ. (1995) Functional detection of MDR1/P170 and MRP/P190-mediated multidrug resistance in tumour cells by flow cytometry. *Br J Cancer* **72**: 543-549.
3. Broxterman HJ, Lankelma J and Pinedo HM. (1996) How to probe clinical tumour samples for P-glycoprotein and multidrug resistance-associated protein. *Eur J Cancer* **32A**: 1024-1033.
4. Litman T, Druley TE, Stein WD and Bates S. (2001) From MDR to MXR: new understanding of multidrug resistance systems, their properties and clinical significance. *Cell Mol Life Sci* **58**: 931-959.
5. Beck WT, Grogan TM, Willman CL et al. (1996) Methods to detect p-glycoprotein-associated multidrug resistance in patients' tumours: Consensus recommendations. *Cancer Res* **56**:3010-3020.
6. Gupta RS. (1988) Intrinsic multidrug resistance phenotype of chinese hamster (rodent) cells in comparison to human cells. *Biochem Biophys Res Commun* **153**: 598-605.
7. McCollum AK, TenEyck CJ, Stensgard B, et al. (2008) P-glycoprotein-mediated resistance to Hsp90-directed therapy is eclipsed by the heat shock response. *Cancer Res* **68**:7419-7427.
8. Collington GK, Hunter J, Allen CN, Simmons NL, Hirst BH. (1992) Polarized efflux of 2',7'-bis(2-carboxyethyl)-5(6)-carboxyfluorescein from cultured epithelial cell monolayers. *Biochem Pharmacol.*; **44**: 417-24.
9. Hunter J, Hirst BH, Simmons NL. (1991) Epithelial secretion of vinblastine by human intestinal adenocarcinoma cell (HCT-8 and T84) layers expressing P-glycoprotein. *Br J Cancer* **64**: 437-44.
10. Roelofsen H, Vos TA, Schippers IJ, et al. (1997) Increased levels of the multidrug resistance protein in lateral membranes of proliferating hepatocyte-derived cells. *Gastroenterology* **112**: 511-21.



11. Hammond CL, Marchan R, Krance SM, and Ballatori N. Glutathione Export during Apoptosis Requires Functional Multidrug Resistance-Associated Proteins. *J Biol Chem* **282**: 14337-14347.
12. Bodey B, Taylor CR, Siegel SE and Kaiser HE. (1995) Immunocytochemical observation of multidrug resistance (MDR) p170 glycoprotein expression in human osteosarcoma cells. The clinical significance of MDR protein overexpression. *Anticancer Res.* **15 (6B)**: 2461-2468.

## IX. TROUBLESHOOTING GUIDE

Problem	Potential Cause	Suggestion
<b>Cells do not exhibit fluorescence after incubation with the detection reagent.</b>	Cell viability is low.	Cells should be in log growth phase. Cell samples cannot be kept longer than 6 hours before the assay. Do not use fixatives, azides or other preservatives. Avoid shear stress, do not vortex, and avoid bubbling.
	Very low concentration of the EFLUXX-ID® Green Detection Reagent	Check the concentration of the reagent.
<b>Fluorescence does not increase after incubation with inhibitor.</b>	Cells do not express any MDR1, MRP1/2 or BCRP.	Use a positive control cell type expressing corresponding ABC transporter.
	Quality of the reagents is compromised.	Check storage, stability and freshness of the reconstituted reagents.
<b>There are differences in MFI (mean fluorescence intensity) values between cell lines.</b>	<b>Detection reagent accumulation may be influenced by cell size, endogenous esterase activity, etc.</b>	Using the inhibitors and calculating the MAF values eliminate these differences.
<b>Inconsistent fluorescence shift using the same cell (irreproducible results)</b>	<b>Inadequate incubation condition.</b>	<b>Always use a water bath (not incubator). Ensure temperature of water bath is 37°C.</b>
	Cell viability is low.	Cells should be in log growth phase. Cell samples cannot be kept longer than 6 hours before the assay. Do not use fixatives, azides or other preservatives. Avoid shear stress, do not vortex, and avoid bubbling.



# Product Manual

## NOTES



# Product Manual

## **GLOBAL HEADQUARTERS**

Enzo Life Sciences Inc.  
10 Executive Boulevard  
Farmingdale, NY 11735  
Toll-Free: 1.800.942.0430  
Phone: 631.694.7070  
Fax: 631.694.7501  
info-usa@enzolifesciences.com

## **EUROPE/ASIA**

Enzo Life Sciences (ELS) AG  
Industriestrasse 17  
CH-4415 Lausen  
Switzerland  
Phone: +41/0 61 926 89 89  
Fax: +41/0 61 926 89 79  
info-ch@enzolifesciences.com

For local distributors and detailed product information visit us online:  
[www.enzolifesciences.com](http://www.enzolifesciences.com)