

# S1P<sub>1</sub>:PKA Redistribution<sup>®</sup> Assay

For High-Content Analysis

067-01.03

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<b>Number</b>	<b>Description</b>
R04-067-01	Recombinant CHO-K1 cells stably expressing the S1P <sub>1</sub> receptor (GenBank Acc. NM_001400) and the catalytic domain of human Protein Kinase A (PKAcad) (GenBank Acc. NM_002730) fused to the N-terminus of enhanced green fluorescent protein (EGFP). CHO-K1 cells are adherent epithelial cells derived from Chinese hamster ovary. Expression of S1P <sub>1</sub> receptor and PKAcad-EGFP are controlled by a standard CMV promoter and continuous expression is maintained by addition of G418 and Zeocin to the culture medium.

**Quantity:** 2 cryo-vials each containing 1.0 x 10<sup>6</sup> cells in a volume of 1.0 ml Cell Freezing Medium.

**Storage:** Immediately upon receipt store cells in liquid nitrogen (vapor phase).

**Warning:** Please completely read these instructions and the material safety data sheet for DMSO before using this product. This product is for research use only. Not intended for human or animal diagnostic or therapeutic uses. Handle as potentially biohazardous material under at least Biosafety Level 1 containment. Safety procedures and waste handling are in accordance with the local laboratory regulations.

**CAUTION:** This product contains Dimethyl Sulfoxide (DMSO), a hazardous material. Please review Material Safety Data Sheet before using this product.

## Introduction

### The Redistribution<sup>®</sup> Technology

The Redistribution<sup>®</sup> Technology monitors the cellular translocation of GFP-tagged proteins in response to drug compounds or other stimuli and allows easy acquisition of multiple readouts from the same cell in a single assay run. In addition to the primary readout, high content assays provide supplementary information about cell morphology, compound fluorescence, and cellular toxicity.

### S1P<sub>1</sub> Receptor Activation Redistribution<sup>®</sup> Assay

Sphingosine-1-phosphate (S1P) is a pleiotropic platelet-derived lysophospholipid involved in the regulation of cell growth and differentiation and thereby important for angiogenesis, embryogenesis, and atherosclerosis [1,2]. There are five known G protein-coupled S1P receptors in mammals. Binding of S1P to the S1P<sub>1</sub> receptor activates G<sub>αi</sub> and G<sub>αo</sub> resulting in adenylyl cyclase inhibition, phospholipase C activation, Ca<sup>2+</sup> mobilization, Ras-Erk activation, and PI3 kinase activation. In this assay, the S1P<sub>1</sub> receptor is stably transfected into a GPCR Reporter Assay for Gs/Gi-coupled Receptors.

This assay system measures translocation of protein kinase A (PKA) in response to changes in the cytoplasmic cAMP concentration. Binding of an agonist to the extracellular parts of the S1P<sub>1</sub> receptor causes activation of the Gi complex at the intracellular face of the receptor. This leads to inhibition of adenylyl cyclase, which catalyzes the formation of cAMP from ATP. In cells stimulated with forskolin that induces high levels of cAMP, PKAcad-GFP is found in a diffuse localization in the cytoplasm. S1P<sub>1</sub> activation leads to inhibition of adenylyl cyclase and thereby less cAMP. This, in turn, leads to aggregation of PKAcad-GFP in cytoplasmic foci [3-5].

The S1P<sub>1</sub>:PKA assay is designed to screen for compounds that modulate cAMP signaling via the S1P<sub>1</sub> receptor. S1P is used as the reference compound.

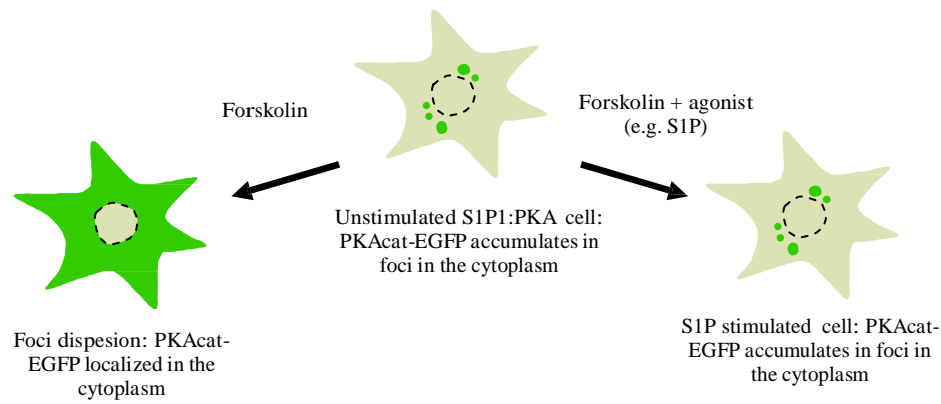


Figure 1. Illustration of the S1P1:PKA translocation event

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## Additional materials required

The following reagents and materials need to be supplied by the user.

- Ham's F12 with L-Glutamine (Thermo Scientific, Fisher Scientific cat.# SH30026)
- Fetal Bovine Serum (FBS) (Thermo Scientific, Fisher Scientific cat.# SH30071)
- Penicillin/Streptomycin, 100X solution (Thermo Scientific, Fisher Scientific cat.# SV30010),
- Trypsin-EDTA, 0.05% (Thermo Scientific, Fisher Scientific cat.# SH30236)
- G418, 50mg/ml (Thermo Scientific, Fisher Scientific cat.# SC30069)
- Zeocin™ Selective Reagent 100 mg/ml (Invitrogen, cat.# R250-05)
- Dimethylsulfoxide (DMSO) (Fisher Scientific, cat.# BP231)
- Dulbecco's Phosphate-Buffered Saline (PBS), w/o calcium, magnesium, or Phenol Red (Thermo Scientific, Fisher Scientific cat.# SH30028)
- Hepes Buffer, 1 M, Free Acid (liquid) (Thermo Scientific, Fisher Scientific cat.# SH30237)
- Fatty-acid free BSA (Fisher Scientific, cat.# NC9227912)
- Sphingosine-1-phosphate (S1P) (Cayman Chemical, cat.# 62570)
- Forskolin (Sigma-Aldrich, cat.# F6886)
- Hoechst 33258 (Fisher Scientific, cat.# AC22989)
- Triton X-100 (Fisher Scientific, cat.# AC21568)
- 10% formalin, neutral-buffered solution (approximately 4% formaldehyde) (Fisher Scientific, cat.# 23-305-510)  
Note: is not recommended to prepare this solution by diluting from a 37% formaldehyde solution.
- 96-well microplate with lid (cell plate) (e.g. Nunc 96-Well Optical Bottom Microplates, Thermo Scientific cat.# 165306)
- Black plate sealer
- Nunc EasYFlasks with Nunclon Delta Surface, T-25, T-75, T-175 (Thermo Scientific, cat.# 156367, 156499, 159910)

## Reagent preparation

The following reagents are required to be prepared by the user.

- Cell Culture Medium: Ham's F12 supplemented with 1% Penicillin-Streptomycin, 0.5 mg/ml G418, 1 mg/ml Zeocin and 10% FBS.
- Cell Freezing Medium: 90% Cell Culture Medium without G418 and Zeocin + 10% DMSO.
- Plate Seeding Medium: Ham's F12 supplemented with 1% Penicillin-Streptomycin, 0.5 mg/ml G418, 1 mg/ml Zeocin, and 1% FBS.
- 10% Fatty-acid free BSA: 1 g Fatty-acid free BSA dissolved in purified water to a final volume of 10 ml.
- Assay Buffer: Ham's F12 supplemented with 1% Penicillin-Streptomycin, 0.1% Fatty-acid free BSA, and 10 mM Hepes Buffer.
- Control Compound Stock: 3 mM S1P stock solution in 10 mM NaOH. Prepare by dissolving 1 mg S1P (MW = 379.5) in 878  $\mu$ l 10 mM NaOH. Vortex the solution and sonicate for about 2 minutes to a milky white suspension. Note: S1P is not fully soluble. Store at -20°C. Note: There is substantial carryover of S1P when a dilution series is prepared. To avoid carryover, change pipet tips after every dilution.
- Control Compound Working Solution: 3  $\mu$ M Working Solution in DMSO. Prepare by diluting the 3 mM S1P stock solution 1:1000 in DMSO.
- Forskolin Agonist Stock: 100 mM Forskolin stock solution in DMSO. Prepare by dissolving 25 mg Forskolin (MW = 410.5) in 609  $\mu$ l DMSO. Store at -20°C.
- Fixing Solution: 10% formalin, neutral-buffered solution (approximately 4% formaldehyde).  
Note: It is not recommended to prepare this solution by diluting from a 37% formaldehyde solution.
- Hoechst Stock: 10 mM stock solution is prepared in DMSO.

- **Hoechst Staining Solution:** 111M Hoechst in PBS containing 0.5% Triton X-100. Prepare by dissolving 2.5 ml Triton X-100 with 500 ml PBS. Mix thoroughly on a magnetic stirrer. When Triton X-100 is dissolved add 5011110 mM Hoechst 33258. Store at 4°C for up to 1 month.

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The following procedures have been optimized for this cell line. It is strongly recommended that an adequately sized cell bank is created containing cells at a low passage number.

### Cell thawing procedure

1. Rapidly thaw frozen cells by holding the cryovial in a 37°C water bath for 1-2 minutes. Do not thaw cells by hand, at room temperature, or for longer than 3 minutes, as this decreases viability.
2. Wipe the cryovial with 70% ethanol.
3. Transfer the vial content into a T75 tissue culture flask containing 25 ml Cell Culture Medium and place flask in a 37°C, 5% CO<sub>2</sub>, 95% humidity incubator.
4. Change the Cell Culture Medium the next day.

### Cell harvest and culturing procedure

For normal cell line maintenance, split 1:12 to 1:24 every 3-4 days. Maintain cells between 5% and 95% confluence. Passage cells when they reach 80-95% confluence. All reagents should be pre-warmed to 37°C.

1. Remove medium and wash cells once with PBS (10 ml per T75 flask and 12 ml per T175 flask).
2. Add trypsin-EDTA (2 ml per T75 flask and 4 ml per T175 flask) and swirl to ensure all cells are covered.
3. Incubate at 37°C for 3-5 minutes or until cells round up and begin to detach.
4. Tap the flask gently 1-2 times to dislodge the cells. Add Cell Culture Medium (6 ml per T75 flask and 8 ml per T175 flask) to inactivate trypsin and resuspend cells by gently pipetting to achieve a homogenous suspension.
5. Count cells using a cell counter or hemocytometer.
6. Transfer the desired number of cells into a new flask containing sufficient fresh Cell Culture Medium (total of 20 ml per T75 flask and 40 ml per T175 flask).
7. Incubate the culture flask in a 37°C, 5% CO<sub>2</sub>, 95% humidity incubator.

### Cell freezing procedure

1. Harvest the cells as described in the “Cell harvest and culturing procedure”, step 1 – 5.
2. Prepare a cell suspension containing 1 x 10<sup>6</sup> cells per ml (5 cryogenic vials = 5 x 10<sup>6</sup> cells).
3. Centrifuge the cells at 250g (approximately 1100 rpm) for 5 minutes. Aspirate the medium from the cells.
4. Resuspend the cells in Cell Freezing Medium at 1 x 10<sup>6</sup> cells per ml until no cell aggregates remain in the suspension.
5. Dispense 1 ml of the cell suspension into cryogenic vials.
6. Place the vials in an insulated container or a cryo-freezing device (e.g. Nalgene "Mr. Frosty" Freezing Container, Thermo Scientific, Fisher Scientific cat.# 15-350-50) and store at -80°C for 16-24 hours.
7. Transfer the vials for long term storage in liquid nitrogen.

### Cell plating procedure

The cells should be seeded into 96-well plates 18-24 hours prior to running the assay. Do not allow the cells to reach over 95% confluence prior to seeding for an assay run. The assay has been validated with cells up to passage 20, split as described in the “Cell harvest and culturing procedure”.

1. Harvest the cells as described in the “Cell harvest and culturing procedure”, step 1-5 using Plate Seeding Medium instead of Cell Culture Medium.
2. Dilute the cell suspension to 80,000 cells/ml in Plate Seeding Medium.
3. Transfer 100 µl of the cell suspension to each well in a 96-well tissue culture plate (cell plate). This gives a cell density of 8000 cells/well.  
Note: At this step, be careful to keep the cells in a uniform suspension.
4. Incubate the cell plate on a level vibration-free table for 1 hour at room temperature (20-25°C). This ensures that the cells attach evenly within each well.
5. Incubate the cell plate for 18-24 hours in a 37°C, 5% CO<sub>2</sub>, 95% humidity incubator prior to starting the assay.

## Assay protocol

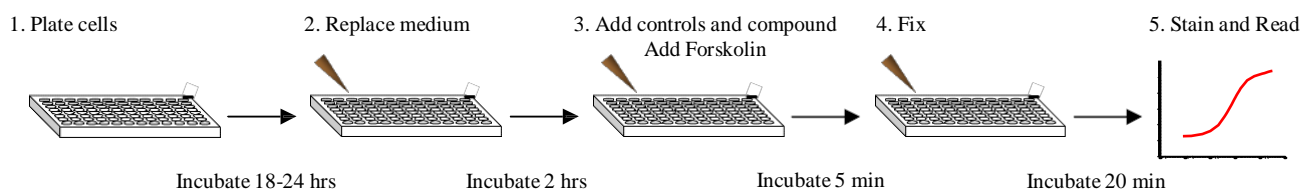


Figure 2: Quick assay workflow overview.

The following protocol is based on 1x 96-well plate.

- Before initiating the assay:
  - Prepare Assay Buffer. Ensure Assay Buffer is pre-warmed to 37°C.
- Gently remove Plate Seeding Medium and wash cell plate once with 100  $\mu$ l Assay Buffer per well.
- Add 100  $\mu$ l Assay Buffer per well.
- Incubate cell plate for 2 hours in a 37°C, 5% CO<sub>2</sub>, 95% humidity incubator.
- In the meantime, prepare controls and test compounds:
  - Dilute controls and test compounds in Assay Buffer to a 4X final concentration. (Volumes and concentrations are indicated below). A final DMSO concentration of 0.25% is recommended, but the assay can tolerate up to 0.5% DMSO final concentration.
  - Mix controls for 1x 96-well plate as indicated below:

	Assay Buffer	Control Stock	DMSO	4X concentration	Final assay concentration	Final DMSO concentration
Negative control	12 ml	----	120 $\mu$ l	1% DMSO	----	0.25%
Positive control*	12 ml	48 $\mu$ l 3 $\mu$ M SIP	72 $\mu$ l	12 nM SIP	3 nM SIP	0.25%

- Prepare 4X Forskolin Agonist Solution (160  $\mu$ M):
  - Prepare fresh by mixing 9.6  $\mu$ l 100 mM Forskolin Stock with 6 ml Assay Buffer. Use the Forskolin Agonist Solution within 20 min after preparation.
- Add 50  $\mu$ l 4X concentrated control or compound solution in Assay Buffer to appropriate wells of the cell plate.
- Add 50  $\mu$ l 4X Forskolin Agonist Solution to appropriate wells of the cell plate.
- Incubate cell plate for 5 minutes in a 37°C, 5% CO<sub>2</sub>, 95% humidity incubator.
- Fix cells by gently decanting the buffer and add 150  $\mu$ l Fixing Solution per well.
- Incubate cell plate at room temperature for 20 minutes.
- Wash the cells 4 times with 200  $\mu$ l PBS per well per wash.
- Decant PBS from last wash and add 100  $\mu$ l 1  $\mu$ M Hoechst Staining Solution.
- Seal plate with a black plate sealer. Incubate at room temperature for at least 30 minutes before imaging. The plate can be stored at 4°C for up to 3 days in the dark.

## Imaging

The translocation of PKAcat-EGFP can be imaged on most HCS platforms and fluorescence microscopes. The filters should be set for Hoechst (350/461 nm) and GFP/FITC (488/509 nm) (wavelength for excitation and emission maxima). Consult the instrument manual for the correct filter settings.

The translocation can typically be analyzed on images taken with a 10x objective or higher magnification.

The primary output in the S1P<sub>1</sub>:PKA Redistribution<sup>®</sup> assay is the formation of spots in the cytoplasm. The data analysis should therefore report an output that corresponds to number, area, or intensity of spots in the cytoplasm.

### Imaging on Thermo Scientific Arrayscan HCS Reader

This assay has been developed on the Thermo Scientific Arrayscan HCS Reader using a 10x objective (0.63X coupler), XF100 filter sets for Hoechst and FITC, and the SpotDetectorV3 BioApplication. The output parameter used was SpotTotalIntenPerObject. The minimally acceptable number of cells used for image analysis in each well was set to 250 cells.

Other BioApplications that can be used for this assay include SpotDetectorV2, CompartmentalAnalysisV2, and ColocalizationV3.

### High Content Outputs

In addition to the primary readout, it is possible to extract secondary high content readouts from the Redistribution<sup>®</sup> assays. Such secondary readouts may be used to identify unwanted toxic effects of test compounds or false positives. In order to acquire this type of information, the cells should be stained with a whole cell dye which allows for a second analysis of the images for determination of secondary cell characteristics.

Examples of useful secondary high content outputs:

Nucleus size, shape, intensity:	Parameter used to identify DNA damage, effects on cell cycle and apoptosis.
Cell number, size, and shape:	Parameter for acute cytotoxicity and apoptosis.
Cell fluorescence intensity:	Parameter for compound cytotoxicity and fluorescence.

The thresholds for determining compound cytotoxicity or fluorescence must be determined empirically. Note that the primary translocation readout in some cases may affect the secondary outputs mentioned above.

## Representative Data Examples

The S1P<sub>1</sub>:PKA Redistribution<sup>®</sup> assay monitors aggregation of a PKAcat-GFP fusion protein in cytoplasmic foci in response to activation of the S1P<sub>1</sub> receptor. S1P is used as reference ligand, and compounds are assayed for their ability to induce cytoplasmic foci formation of PKAcat-GFP in cells that are stimulated with forskolin to induce high levels of cAMP.

Representative images of S1P<sub>1</sub>:PKA Redistribution<sup>®</sup> cells treated with S1P are shown in Figure 3.

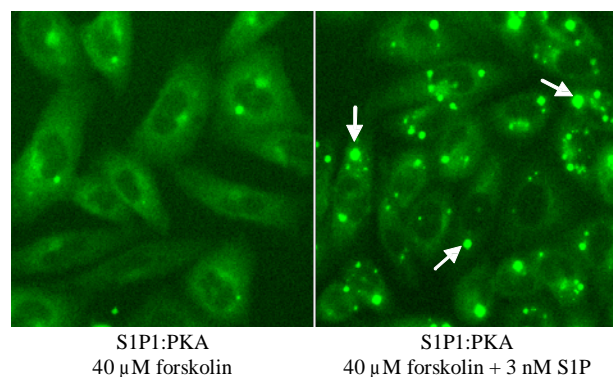


Figure 3. Cytoplasmic foci formation of PKAcat-GFP. Cells expressing the S1P<sub>1</sub> receptor were treated with 40 μM forskolin for 5 min in the presence or absence of 3 nM S1P. Activation of the receptor inhibits the forskolin-induced dispersion of PKAcat-GFP aggregates. Arrows indicated the cytoplasmic foci detected by the image analysis algorithm.

A representative concentration response curve of the reference compound S1P in the S1P1:PKA assay is shown in Figure 4. The EC<sub>50</sub> of S1P in the assay is approximately 150 pM.

**S1P concentration response curve in the S1P1:PKA Redistribution assay**

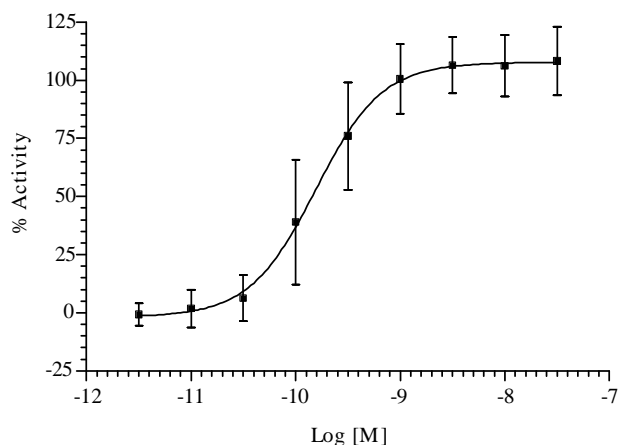


Figure 4. S1P concentration response in the S1P1:PKA assay. Concentration response was measured in 9 point half log dilution series (n=32). The EC<sub>50</sub> of S1P is ~150 pM. Cells were treated with S1P in the presence of forskolin for 5 min. Cells were then fixed and cytoplasmic spot formation was measured using the Cellomics ArrayScan V<sup>TI</sup> Reader and the SpotDetectorV3 BioApplication. % activity was calculated relative to the positive (3 nM S1P) and negative control (0.25% DMSO).

## Product qualification

Assay performance has been validated with an average  $Z' = 0.46 \pm 0.05$ . The cells have been tested for viability. The cells have been tested negative for mycoplasma.

## Related Products

Product #	Type	Product description	Cell line
R04-017_02	Profiling & Screening	Gq-coupled GPCRs – NFATc1 Redistribution <sup>®</sup> Assay	U2OS
R04-045_02	Profiling & Screening	Gs/Gi-coupled GPCRs – PKA Redistribution <sup>®</sup> Assay	CHO-K1
R04-046_01	Profiling & Screening	β2-AR:PKA Redistribution <sup>®</sup> Assay	CHO-K1
R04-048_01	Profiling & Screening	NK1:NFATc1 Redistribution <sup>®</sup> Assay	U2OS
R04-047_01	Profiling & Screening	GlucagonR:PKA Redistribution <sup>®</sup> Assay	CHO-K1
R04-088_01	Profiling & Screening	M1:NFATc1 Redistribution <sup>®</sup> Assay	U2OS
R04-072_01	Profiling & Screening	M2:PKA Redistribution <sup>®</sup> Assay	CHO-K1
R04-073_01	Profiling & Screening	M3:NFATc1 Redistribution <sup>®</sup> Assay	U2OS
R04-078_01	Profiling & Screening	AT1:NFATc1 Redistribution <sup>®</sup> Assay	U2OS
R04-079_01	Profiling & Screening	MCH1:NFATc1 Redistribution <sup>®</sup> Assay	U2OS
R04-081_01	Profiling & Screening	MOR1:PKA Redistribution <sup>®</sup> Assay	CHO-K1

## References

1. Rosen H & Goetzl EJ, Nature Rev Immunol., 5, 560-570, 2005.
2. Kostenis E, J Cell Biochem., 92, 923-936, 2004.
3. Feliciello, A. et al., J. Mol. Biol.; 308, 99-114, 2001.
4. Almholt, K. et al., Cell Signal.; 16, 907-20, 2004.
5. Zaccolo, M. et al., Nat. Cell Biol.; 2, 25-29, 2000.



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For European customers:

The S1P1:PKA Redistribution cell line is genetically modified with vectors expressing S1P<sub>1</sub> receptor and PKAcat fused to EGFP. As a condition of sale, use of this product must be in accordance with all applicable local legislation and guidelines including EC Directive 90/219/EEC on the contained use of genetically modified organisms.

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