Human Aryl Hydrocarbon Receptor (AhR) Reporter Assay System

3x 32 Assays in 96-well Format
Product # IB06001-32

Technical Manual
(version 7.2)

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3x 32 Assays in 96-well Format

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I. Description

- Background -

While technically not a nuclear receptor, the AhR is mechanistically and functionally similar to members of that super-family, being both a receptor and a ligand-activated transcription factor. More formally, the AhR is a member of the basic helix-loop-helix, Per-Arnt-Sim family of transcription factors. AhR is a xenobiotic-sensing receptor responsible for the adverse toxicologic effects elicited by various polycyclic aromatic hydrocarbon environmental and industrial pollutants, perhaps the most infamous being 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). The basic mechanism of action of dioxin and related compounds has been extensively studied, in particular as it relates to regulation of cytochrome P450 1A1 (CYP1A1).

The AhR is present in the cytosol of most cell types where, in the non-active state, it is in a complex with chaperone proteins such as Hsp90. Binding of a polycyclic aromatic hydrocarbon to AhR leads to nuclear translocation and hetero-dimerization with its partner protein ARNT. The AhR-ARNT hetero-dimer binds to specific cognate DNA sequence elements known as dioxin/xenobiotic response elements (DRE/XRE) present in the regulatory region of a variety of target genes. Binding of AhR:ARNT to these elements, and subsequent recruitment of transcription co-activator complexes, induces the transcription of a battery of target genes, including xenobiotic-metabolizing enzymes such as CYP1A1, CYP1A2, CYP2B1 and UGT1A6. In addition, genes affected directly and indirectly by the TCDD/AhR-complex code for both inhibitory and stimulatory growth factors and their gene products affect cellular growth and differentiation leading to tumor promotion and carcinogenicity in addition to induced toxic responses.

- The Assay System -

INDIGO’s Aryl Hydrocarbon Receptor (AhR) Reporter Cells include the luciferase reporter gene functionally linked to an AhR-responsive promoter. Thus, quantifying changes in luciferase expression in the treated reporter cells provides a sensitive surrogate measure of the changes in AhR activity. The principal application of this assay is in the screening of test samples to quantify any functional activity, either agonist or antagonist, that they may exert against human AhR.

AhR Reporter Cells are prepared using INDIGO’s proprietary CryoMite™ process. This cryo-preservation method yields exceptional cell viability post-thaw, and provides the convenience of immediately dispensing healthy, division-competent reporter cells into assay plates. There is no need for cumbersome intermediate treatment steps such as spin-and-rinse of cells, viability determinations, or cell titer adjustments prior to assay setup.

INDIGO’s Human AhR assay kit is an all-inclusive system. In addition to AhR Reporter Cells, this kit provides two optimized media for use during cell culture and in diluting the user’s test samples, a reference agonist, Luciferase Detection Reagent, and a cell culture-ready assay plate.

- The Assay Chemistry -

INDIGO’s cell-based assay formats capitalize on the extremely low background, high-sensitivity, and broad linear dynamic range of bio-luminescence reporter gene technology. Reporter Cells incorporate the cDNA encoding beetle luciferase, a 62 kD protein originating from the North American firefly (Photinus pyralis). Luciferase catalyzes the mono-oxidation of D-luciferin in a Mg$^{2+}$-dependent reaction that consumes O$_2$ and ATP as co-substrates, and yields as products oxyluciferin, AMP, PP$_i$, CO$_2$, and photon emission. Luminescence intensity of the reaction is quantified using a luminometer, and is reported in terms of Relative Light Units (RLU’s).

INDIGO’s assay kits feature a luciferase detection reagent specially formulated to provide stable light emission between 5 and 90+ minutes after initiating the luciferase reaction. Incorporating a 5 minute reaction-rest period ensures that light emission profiles attain maximal stability, thereby allowing assay plates to be processed in batch. By doing so, the signal output from all sample wells, from one plate to the next, may be directly compared within an experimental set.
• Preparation of Test Compounds •

Test compounds are typically solvated at high-concentration in DMSO and stored frozen as master stocks. Immediately prior to setting up an assay, the master stocks are serially diluted using one of two alternative strategies:

1.) As described in Step 7, and depicted in Appendix 1 for the reference agonist MeBIO, Compound Screening Medium (CSM) may be used as the diluent to make serial dilutions of test compounds to achieve the desired final assay concentration series.

Alternatively, if test compound solubility is expected to be problematic,

2.) DMSO may be used to make serial dilutions, thereby generating 1,000x-concentrated stocks for each independent test concentration. Treatment media are then prepared using CSM to make final 1,000-fold dilutions of the prepared DMSO dilution series.

Regardless of the dilution method used, the final concentration of total DMSO carried over into assay wells should never exceed 0.4%. Significant DMSO-induced cytotoxicity can be expected above 0.4%.

NOTE: CSM is formulated to help stabilize hydrophobic test compounds in the aqueous environment of the assay mixture. Nonetheless, high concentrations of extremely hydrophobic test compounds diluted in CSM may lack long-term stability and/or solubility, especially if further stored at low temperatures. Hence, it is recommended that test compound dilutions are prepared in CSM immediately prior to assay setup, and are considered to be ‘single-use’ reagents.

• Assay Scheme •

Figure 1. Assay workflow.

In brief, 200 µl of Reporter Cells is dispensed into wells of the assay plate and pre-incubated for 4-6 hours. Following the pre-incubation period, culture media are discarded and 200 µl/well of the prepared 1x-concentration treatment media are added. Following 22-24 hr incubation, discard the treatment media and add Luciferase Detection Reagent. The intensity of light emission (in units of ‘Relative Light Units’; RLU) from each assay well is quantified using a plate-reading luminometer.
Agonist analyses of Human AhR Reporter Cells were performed according to the protocol described in this Technical manual, using the reference agonists MeBIO (provided), FICZ (6-Formylindolo(3,2-b)carbazole; Enzo), ITE (2-(1H-indole-3-ylcarbonyl)-4-thiazolecarboxylic methyl ester; Tocris), β-Napthoflavone (Sigma), Omeprazole and Pifthrin-α-hydrobromide (each from Tocris). Luminescence was quantified using a GloMax-Multi+ luminometer (Promega). Average relative light units (RLU) and corresponding standard deviation (SD) values were determined for each treatment concentration (n ≥ 6). Fold-activation (i.e., S/B) and Z’ values were calculated as described by Zhang, et al. (1999)\textsuperscript{1}. Non-linear regression and EC\textsubscript{50} analyses were performed using GraphPad Prism software.

The reference agonist MeBIO yielded an EC\textsubscript{50} = 4 nM, and a Z’ value of 0.69, confirming the robust performance of this assay, and it’s suitability for HTS\textsuperscript{1}.


\[ Z' = 1 - \frac{3 \times (SD_{\text{Control}} + SD_{\text{Background}})}{(RLU_{\text{Control}} - RLU_{\text{Background}})} \]
Figure 3. Antagonist dose-response analyses of Human AhR.
Antagonist analyses of Human AhR Reporter Cells were performed according to the protocol described in this Technical manual, using the reference antagonists GNF351 (Calbiochem) and CH 223191 (Tocris).
II. Product Components & Storage Conditions

This Human AhR Assay kit contains materials to perform three distinct groups of assays in a 96-well plate format. Reagents are configured so that each group will comprise 32 assays. If desired, however, reagents may be combined to perform either 64 or 96 assays.

The individual aliquots of Reporter Cells are provided as single-use reagents. Once thawed, reporter cells can NOT be refrozen or maintained in extended culture with any hope of retaining downstream assay performance. Therefore, extra volumes of these reagents should be discarded after assay setup.

Assay kits are shipped on dry ice. Upon receipt, individual kit components may be stored at the temperatures indicated on their respective labels. Alternatively, the entire kit may be further stored at -80°C.

To ensure maximal viability, Reporter Cells must be maintained at -80°C until immediately prior to use.

The date of product expiration is printed on the Product Qualification Insert (PQI) enclosed with each kit.

<table>
<thead>
<tr>
<th>Kit Components</th>
<th>Amount</th>
<th>Storage Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>AhR Reporter Cells</td>
<td>3 x 0.60 mL</td>
<td>-80°C</td>
</tr>
<tr>
<td>Cell Recovery Medium (CRM)</td>
<td>2 x 10.5 mL</td>
<td>-20°C</td>
</tr>
<tr>
<td>Compound Screening Medium (CSM)</td>
<td>1 x 45 mL</td>
<td>-20°C</td>
</tr>
<tr>
<td>MeBio, 1.0 mM (in DMSO) (positive control for AhR activation)</td>
<td>1 x 30 µL</td>
<td>-20°C</td>
</tr>
<tr>
<td>Detection Substrate</td>
<td>3 x 2.0 mL</td>
<td>-80°C</td>
</tr>
<tr>
<td>Detection Buffer</td>
<td>3 x 2.0 mL</td>
<td>-20°C</td>
</tr>
<tr>
<td>Plate frame</td>
<td>1</td>
<td>ambient</td>
</tr>
<tr>
<td>Snap-in, 8-well strips (white, sterile, cell-culture ready)</td>
<td>12</td>
<td>ambient</td>
</tr>
</tbody>
</table>

III. Materials to be Supplied by the User

The following materials must be provided by the user, and should be made ready prior to initiating the assay procedure:

**DAY 1**
- cell culture-rated laminar flow hood.
- 37°C, humidified 5% CO₂ incubator for mammalian cell culture.
- 37°C water bath.
- 70% alcohol wipes
- 8- or 12-channel electronic, repeat-dispensing pipettes & sterile tips
- disposable media basins, sterile.
- sterile multi-channel media basins (such as the Heathrow Scientific "Dual-Function Solution Basin"), or deep-well plates, or appropriate similar vessel for generating dilution series of reference compound(s) and test compound(s).
- **Optional:** antagonist reference compound.
- **Optional:** clear 96-well assay plate, sterile, cell culture treated, for viewing cells on Day 2.

**DAY 2** plate-reading luminometer.
IV. Assay Protocol

Review the entire Assay Protocol before starting. Completing the assay requires an overnight incubation. Steps 1-11 are performed on Day 1, requiring less than 2 hours of bench work and a 4 hr incubation step to complete. Steps 12-18 are performed on Day 2, and require less than 1 hour to complete.

• A word about Antagonist-mode assay setup •

Receptor inhibition assays expose the Reporter Cells to a constant, sub-maximal concentration (typically between EC$_{50}$ – EC$_{85}$) of a known agonist AND the test compound(s) to be evaluated for antagonist activity. This AhR assay kit includes a 1.0 mM stock solution of MeBio, an activator of AhR that may be used to setup antagonist-mode assays. 28 nM MeBio typically approximates EC$_{85}$ in this cell-based assay (see Figure 2). Hence, it presents a reasonable assay concentration of agonist to be used when screening test compounds for inhibitory activity to AhR.

We find that adding the challenge agonist to a bulk volume of CSM, at the desired final assay concentration, is the most efficient and precise method of setting up antagonist assays, and it is the method presented in Step 7b of the following protocol.

DAY 1 Assay Protocol: All steps must be performed using aseptic technique.

1.) Remove the 2 tubes of Cell Recovery Medium (CRM) from freezer storage, thaw and equilibrate to 37°C using a water bath.

2.) Rapid Thaw of the Reporter Cells: First, retrieve one or two tubes of CRM from the 37°C water bath and sanitize the outside surface(s) with a 70% ethanol swab.

   Second, retrieve Reporter Cells from -80°C storage: 1 tube for 32 assay wells, 2 tubes for 64 assay wells, and 3 tubes for 96 assay wells. Without delay, perform a rapid thaw of the frozen cells by transferring 6.4 ml of pre-warmed CRM into each tube of frozen cells. Recap the tube of Reporter Cells and immediately place it in a 37°C water bath for 5 - 10 minutes. The resulting volume of cell suspension will be 7.0 ml per tube.

3.) Retrieve the tube of Reporter Cell Suspension from the water bath and sanitize the outside surface with a 70% alcohol swab.

4.) Gently invert the tube of Reporter Cells several times to disperse cell aggregates and gain a homogenous cell suspension. Dispense 200 µl / well of cell suspension into the Assay Plate.

   NOTE 4.1: Take special care to prevent cells from settling during the dispensing period. Allowing cells to settle during the transfer process, and/or lack of precision in dispensing uniform volumes across the assay plate will cause well-to-well variation (increased Standard Deviation) in the assay.

   NOTE 4.2: Users sometimes prefer to examine the reporter cells using a microscope. If so, the extra volume of cell suspension provided with each kit may be dispensed (200 µl/well) into a clear 96-well cell culture treated assay plate. Process the clear assay plate in identical manner to those reporter cells contained in the white assay plate.

5.) Pre-incubate reporter cells: Place the assay plate into a 37°C, ≥ 85% humidity, 5% CO$_2$ incubator for 4 - 6 hours.
Near the end of the 4-6 hour pre-incubation period:

6.) Remove Compound Screening Medium (CSM) from freezer storage and thaw in a 37°C water bath.

7.) Prepare the Test Compound and Reference Compound treatment media at the desired final assay concentrations: Use CSM to prepare an appropriate dilution series of the reference and test compound stocks. Prepare treatment media at the desired final assay concentrations. In Step 9, the prepared treatment media are dispensed at 200 µl / well into the assay plate. Manage dilution volumes carefully; this assay kit provides 45 ml of CSM.

   NOTE: Total DMSO carried over into assay reactions should never exceed 0.4%.

   a. Agonist-mode assays. This AhR Assay kit includes a 1.0 mM stock solution of MeBio, a potent activator of AhR. The following 7-point treatment series, prepared in serial 5-fold decrements, provides a suitable dose-response: 1000, 200, 40, 8.0, 1.6, 0.32, and 0.064 nM (final assay concentrations), and including a 'no treatment' control. APPENDIX 1 provides an example for generating such a dilution series.

   ~ or ~

   b. Antagonist-mode assays. When setting antagonist assays, first supplement a bulk volume of CSM with the challenge agonist to achieve the desired final assay concentration (refer to "A word about antagonist-mode assay setup", pg. 8). The agonist-supplemented CSM is then used to generate dilutions of test compound samples to achieve the desired final assay concentrations.

8.) At the end of the cell pre-incubation period: Discard the culture media.

   NOTE: Because the assay plate is composed of a frame with snap-in strip-wells, the practice of physically ejecting media is NOT advised. Do not touch the well bottom, or run the tip of the aspiration device around the bottom circumference of the assay well. Such practices will result in destruction of the reporter cells and greatly increased well-to-well variability. Complete removal of the media is efficiently performed by tilting the plate on edge and aspirating media using an 8-pin manifold (e.g., Wheaton Science Microtest Syringe Manifold, # 851381) affixed to a vacuum-trap apparatus.

9.) Dispense 200 µl of each treatment media into appropriate wells of the assay plate.

10.) Transfer the assay plate into a 37°C, humidified 5% CO₂ incubator for 22 - 24 hours.

   NOTE: Ensure a high-humidity (≥ 85%) environment within the cell culture incubator. This is critical to prevent the onset of deleterious "edge-effects" in the assay plate.

11.) For greater convenience on Day 2, retrieve the appropriate number of vials of Detection Substrate and Detection Buffer from freezer storage and place them in a dark refrigerator (4°C) to thaw overnight.
DAY 2 Assay Protocol: Subsequent manipulations do not require special regard for aseptic technique, and may be performed on a bench top.

12.) 30 minutes before intending to quantify receptor activity, remove Detection Substrate and Detection Buffer from the refrigerator and place them in a low-light area so that they may equilibrate to room temperature. Once at room temperature, gently invert each tube several times to ensure homogenous solutions.

   NOTE: Do NOT actively warm Detection Substrate above room temperature. If these solutions were not allowed to thaw overnight at 4°C, a room temperature water bath may be used to expedite thawing.

13.) Set the plate-reader to “luminescence” mode. Set the instrument to perform a single 5 second “plate shake” prior to reading the first assay well. Read time may be set to 0.5 second (500 mSec) per well, or less.

14.) Immediately before proceeding to Step 15: To read 32 assay wells, transfer the entire volume of 1 vial of Detection Buffer into 1 vial of Detection Substrate, thereby generating a 4 ml volume of Luciferase Detection Reagent (LDR). Mix gently to avoid foaming.

15.) Following 22 - 24 hours of incubation, retrieve the assay plate from the incubator and discard all media contents (as before in Step 8).

16.) Add 100 µl of LDR to each well of the assay plate.

17.) Allow the assay plate to rest at room temperature for at least 5 minutes following the addition of LDR. Do not shake the assay plate during this period.

18.) Quantify luminescence.
V. Related Products

Human AhR Assay Kit Products

<table>
<thead>
<tr>
<th>Product No.</th>
<th>Product Descriptions</th>
</tr>
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<tbody>
<tr>
<td>IB06001-32</td>
<td>3x 32 AhR assays; strip-wells in 96-well plate frame</td>
</tr>
<tr>
<td>IB06001</td>
<td>1x 96-well format AhR assays</td>
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Rat AhR Assay Kit Products

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<th>Product No.</th>
<th>Product Descriptions</th>
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<tr>
<td>R06001-32</td>
<td>3x 32 AhR assays; strip-wells in 96-well plate frame</td>
</tr>
<tr>
<td>R06001</td>
<td>1x 96-well format AhR assays</td>
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</tbody>
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Bulk assay reagents may be custom manufactured to accommodate any scale of HTS. Please Inquire.

LIVE Cell Multiplex (LCM) Assay Products

<table>
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<tr>
<th>Product No.</th>
<th>Product Descriptions</th>
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<tbody>
<tr>
<td>LCM-01</td>
<td>Reagents to perform 96 Live Cell Assays in 1x96-well, or 2x48-well, or 3x32-well assay plate formats</td>
</tr>
<tr>
<td>LCM-05</td>
<td>Reagents in 5x-bulk volume to perform 480 Live Cell Assays in any combination of 1x96-, 2x48-, or 3x32-well assay plate formats</td>
</tr>
<tr>
<td>LCM-10</td>
<td>Reagent in 10x-bulk volume to perform 960 Live Cell Assays in any combination of 1x96-, 2x48-, or 3x32-well assay plate formats</td>
</tr>
</tbody>
</table>

Please refer to INDIGO Biosciences website for updated product offerings.

www.indigobiosciences.com

VI. Limited Use Disclosures

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APPENDIX 1