

MI Agar

Intended Use

MI Agar* is a chromogenic/fluorogenic medium used to detect and enumerate *Escherichia coli* and total coliforms in drinking water by the membrane filtration technique. It conforms with the U.S. Environmental Protection Agency (USEPA) Approved Method 1604: *Total Coliforms and Escherichia coli in Water by Membrane Filtration Using a Simultaneous Detection Technique (MI Medium)*.

* U.S. Patent No. 6,063,590. Manufactured under license. Commercialization of dehydrated culture medium as prepared medium is prohibited.

Summary and Explanation

Coliform bacteria are species that inhabit the intestines of warm-blooded animals or occur naturally in soil, vegetation and water. They are usually found in fecally-polluted water and are often associated with disease outbreaks. Although these bacteria are not usually pathogenic themselves, their presence in drinking water indicates the possible presence of other pathogens. *E. coli* is one species in this group of coliform bacteria. Since it is always found in feces, it is a more direct indicator of fecal contamination and the possible presence of enteric pathogens.

Chromogens or fluorogens have been used for many years to detect and identify total coliforms (TC) and *E. coli*. Some methods use liquid media in a multiple-tube-fermentation (MTF) test, a presence-absence (PA) format or other tube tests. Agar media are also used for direct plating or membrane filtration

(MF) technology. However, standard MF technology for the detection of TC and fecal coliforms requires the use of several different types of media and two different incubation temperatures.¹

The newest technology developed by the USEPA for testing drinking water is a single membrane filtration technique where no membrane filter transfers are required.^{1,4} The medium is named after the two enzyme substrates included in the formulation: a fluorogen, 4-Methylumbelliferyl- β -D-galactopyranoside (MUGal) and a chromogen, Indoxyl- β -D-glucuronide (IBDG). MI Agar can simultaneously detect and enumerate both TC and *E. coli* in water samples in 24 hours or less based on their specific enzyme activities. MI Agar detects the presence of the bacterial enzymes β -galactosidase and β -glucuronidase produced by TC and *E. coli*, respectively.

MI Agar is approved for use by certified drinking water laboratories for microbial analysis of potable water. Other uses include recreational, surface or marine water, bottled water, groundwater, well water, treatment plant effluents, water from drinking water distribution line, drinking water source water and possibly foods.⁵

As referenced in USEPA method 1604, this method has a detection limit of one *E. coli* and/or one total coliform per sample volume or dilution tested.⁵ The false-positive and false negative rates for *E. coli* are both 4.3%.⁵ Specificity for *E. coli* is 95.7%

User Quality Control

Identity Specifications

Difco™ MI Agar

Dehydrated Appearance: Light beige, free-flowing, homogeneous.

Solution: 3.65% solution, soluble in purified water upon boiling. Solution is light to medium tan, very slightly to slightly opalescent.

Prepared Appearance: Light tan, clear to very slightly opalescent. Upon removal from 2-8°C storage, plates may exhibit a crystal precipitate that disappears upon warming to room temperature. This is a typical characteristic of the medium and is acceptable.

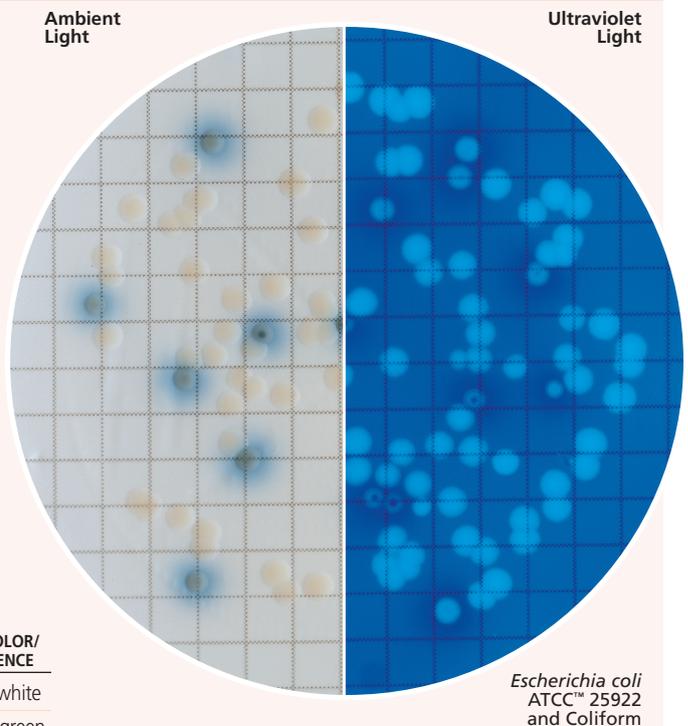
Reaction of 3.65% Solution at 25°C: pH 6.95 ± 0.2

Cultural Response

Difco™ MI Agar

Prepare the medium per label directions. Inoculate using the membrane filtration technique and incubate at 35 ± 2°C for 20-24 hours. Count all blue or indigo colonies under ambient light. Expose MI Agar plates to long-wave ultraviolet light (366 nm) and count all fluorescent colonies.

ORGANISM	ATCC™	INOCULUM CFU	RECOVERY	COLONY COLOR/ FLUORESCENCE
<i>Enterobacter aerogenes</i>	13048	20-80	Good	Tan / blue-white
<i>Escherichia coli</i>	25922	20-80	Good	Blue / blue-green
<i>Proteus mirabilis</i>	43071	20-80	Good	Tan / none
<i>Pseudomonas aeruginosa</i>	27853	20-80	Marked to complete inhibition	Tan / none



and for total coliforms is 93.1%.⁵ The single lab recovery of *E. coli* is 97.9% of the heterotrophic plate count (pour plate) and 115% of the R2A spread plate count.⁵ For *Klebsiella pneumoniae* and *Enterobacter aerogenes*, recoveries are 87.5% and 85.7% of the heterotrophic plate count and 89.3% and 85.8% of the R2A spread plate method, respectively.⁵

Principles of the Procedure

MI Agar contains peptone as a source of nitrogen, carbon and amino acids. Yeast extract provides trace elements, vitamins and amino acids. Lactose is a fermentable carbohydrate and carbon source. Sodium chloride maintains osmotic equilibrium. Monopotassium and dipotassium phosphates offer buffering capabilities. Sodium lauryl sulfate and sodium desoxycholate are selective against gram-positive bacteria. *E. coli* that produce the enzyme β -D-glucuronidase cleave the chromogen indoxyl- β -D-glucuronide (IBDG) to form a blue- or indigo-colored compound. The β -galactosidase produced by total coliforms cleaves the fluorogen 4-methylumbelliferyl- β -D-galactopyranoside (MUGal), producing 4-methylumbelliferone, a fluorescent compound when exposed to long-wave UV light (366 nm). Agar is the solidifying agent. Cefsulodin is added to inhibit gram-positive bacteria and some non-coliform gram-negative bacteria that may cause false positives.

Formula

Difco™ MI Agar

Approximate Formula* Per Liter		
Proteose Peptone No. 3.....	5.0	g
Yeast Extract	3.0	g
D-Lactose.....	1.0	g
MUGal (4-Methylumbelliferyl- β -D-galactopyranoside).....	0.1	g
Indoxyl- β -D-glucuronide (IBDG)	0.32	g
Sodium Chloride	7.5	g
Dipotassium Phosphate.....	3.3	g
Monopotassium Phosphate.....	1.0	g
Sodium Lauryl Sulfate.....	0.2	g
Sodium Desoxycholate	0.1	g
Agar	15.0	g

*Adjusted and/or supplemented as required to meet performance criteria.

Directions for Preparation from Dehydrated Product

1. Suspend 36.5 g of the powder in 1 L of purified water. Mix thoroughly.
2. Heat with frequent agitation and boil for 1 minute to completely dissolve the powder.
3. Autoclave at 121°C for 15 minutes and cool in a 50°C water bath.
4. Add 5 mL of a freshly prepared 1 mg/mL filter-sterilized solution of cefsulodin per liter of tempered agar medium (final concentration of 5 μ g/mL).
5. Dispense 5 mL amounts into 9 × 50 mm or 15 × 60 mm plates and allow to solidify.
6. Test samples of the finished product for performance using stable, typical control cultures.

NOTE: Upon removal from 2-8°C storage, plates may exhibit a crystal precipitate that disappears upon warming to room temperature. This is a typical characteristic of the medium and is acceptable.

Procedure

1. Collect and prepare water samples in accordance to recommended guidelines.^{6,7}
2. Test recommended sample volumes following the membrane filtration procedure described in *Standard Methods for the Examination of Water and Wastewater*.⁶ For drinking water, test 100 mL samples. For other samples, select sample volumes to produce 20-80 colonies of the target organism on the membrane filter. With water of good quality, the occurrence of coliforms generally will be minimal. Therefore, count all coliform colonies (disregarding the lower limit of 20 cited above) and use the formula given below to obtain coliform density.⁶
3. After sample has been filtered, aseptically remove membrane filter from filter base and roll it onto MI Agar to avoid the formation of bubbles between the membrane and the agar surface.
4. Invert inoculated plates and incubate at 35 ± 0.5°C for 20-24 hours.
5. After incubation, count and record the number of blue or indigo colonies under normal/ambient light to obtain *E. coli* count.
6. Expose each MI Agar plate to long-wave ultraviolet light (366 nm), and count and record all fluorescent colonies plus all blue, non-fluorescent colonies to obtain a total coliform count.

For drinking water, calculate and report the number of *E. coli* and Total Coliform colonies per 100 mL of sample using the formula:

*FC = Fluorescent colonies

**NFC = Non-fluorescent colonies

Expected Results

E. coli produces blue or indigo colonies under normal/ambient light. Total coliforms produce blue/green fluorescent colonies (*E. coli*), blue/white fluorescent colonies (total coliforms other than *E. coli*) and blue/green colonies with fluorescent edges (*E. coli*). In addition, any blue, non-fluorescent colonies (also *E. coli*) found should be added to the total coliform count.¹

Refer to the USEPA Microbiology Methods Manual, Part II, Section C, 3.5 for general counting rules.⁸

Limitations of the Procedure

1. For water samples other than drinking water, choose a water sample size that will result in 20-80 colonies per filter. The ideal volume for *E. coli* enumeration may not be optimum for total coliform enumeration, and vice versa. However,

since blue *E. coli* colonies were found to be clearly visible on a total coliform background that was too numerous to count, this should be of minor importance for drinking water compliance purposes, and multiple volumes or dilutions of other water types should provide accurate enumeration.¹

2. Water samples containing colloidal or suspended particulate material can clog the membrane filter, preventing adequate filtration or causing the spread of bacterial colonies. This could interfere with identification of the target colonies. However, the blue *E. coli* colonies can often be counted on plates with heavy particulate matter or high concentrations of total bacteria.¹
3. The presence of some lateral diffusion of blue color away from the target *E. coli* colonies can affect enumeration and colony picking on plates with high concentrations of *E. coli*. This problem should not affect filters with low counts, such as those obtained with drinking water or properly diluted samples.¹
4. Colonies that are tiny, flat or peaked pinpoint blue, with a size of less than 0.5 mm in diameter on filters containing less than 200 colonies may be due to species other than *E. coli*. These colonies occur occasionally in low numbers and should be excluded from the count of *E. coli* colonies, which are usually much larger in size (1-3 mm in diameter). The small colonies have never been observed in the absence of typical *E. coli* but, if they should occur, the sample should not be considered *E. coli*-positive unless at least one colony has been verified by another method.¹
5. Bright green, fluorescent, non-blue colonies, observed along with the typical blue/white or blue/green fluorescent TC colonies, may be species other than coliforms. These colonies generally occur in low numbers ($\leq 5\%$) and can usually be distinguished from the total coliforms. An increase in the number of bright green colonies may indicate an unusual sample population or a breakdown of the cefsulodin in the medium.¹
6. Minimize the exposure of MI Agar to light before and during incubation, as light may destroy the chromogen.

References

1. Brenner, Rankin, Roybal, Stelma, Scarpino and Dufour. 1993. Appl. Environ. Microbiol. 59:3534.
2. Brenner, Rankin and Sivaganesan. 1996. J. Microbiol. Methods. 27:111.
3. Brenner, Rankin, Sivaganesan and Scarpino. 1996. Appl. Environ. Microbiol. 62:203.
4. U.S. Environmental Protection Agency. 2000. Membrane filter method for the simultaneous detection of total coliforms and *Escherichia coli* in drinking water. Publication EPA 600-R-00-013. Office of Research and Development, USEPA, Cincinnati, Ohio.
5. U.S. Environmental Protection Agency. 2002. Method 1604: Total coliforms and *Escherichia coli* in water by membrane filtration using a simultaneous detection technique (MI medium). Publication EPA-821-R-02-024. USEPA Office of Water (4303T), Washington, DC.
6. Eaton, Rice and Baird (ed.). 2005. Standard methods for the examination of water and wastewater, 21st ed., online. American Public Health Association, Washington, D.C.
7. ASTM International. 2007. 2007 ASTM Annual book of standards 11: Water and environmental technology. ASTM International, West Conshohocken, Pa.
8. Bordner, Winter and Scarpino (ed.). 1978. Microbiological methods for monitoring the environment: water and wastes. Publication EPA-600/8-78-017. Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio.

Availability

Difco™ MI Agar

EPA

Cat. No. 214882 Dehydrated – 100 g
214883 Dehydrated – 500 g

BBL™ MI Agar

EPA

Cat. No. 214986 Prepared Plates – Pkg. of 20*
214985 Prepared Plates – Ctn. of 100*

*Store at 2-8°C.