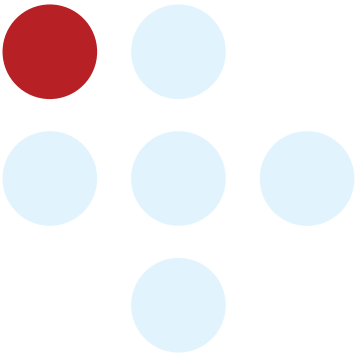
FFPE *in situ* hybridization using double-labeled Fluorescein or DIG miRCURY LNA™ microRNA Detection probes

Instruction manual v1.0



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Abbreviations. FFPE: formalin-fixed and paraffin-embedded. ISH: *In situ* hybridization. LNA™: locked nucleic acid. Prot-K: Proteinase-K. RT: room temperature. AP: alkaline phosphatase. DIG: digoxigenin. PFA: paraformaldehyde.

Product summary

Content

The miRCURY LNA™ microRNA Detection probes, positive and negative controls, and the miRCURY LNA™ microRNA Detection, microRNA ISH Buffer Set (FFPE) are available for setting-up in situ hybridization (ISH) experiments for specific microRNA detection. This Instruction Manual addresses the use of miRCURY LNA™ microRNA Detection probes for ISH experiments and includes Exiqon's "One-day microRNA ISH protocol" developed specifically for ISH on formalin-fixed paraffin embedded (FFPE) tissue samples. However, the protocol can be easily adapted to use for ISH on fresh frozen tissue: http://www.exiqon.com/ls/Documents/Scientific/FrFr-ISH-supplementary-protocol.pdf

The One-day microRNA ISH protocol minimizes time-consuming optimization steps and enables a fast and optimal microRNA ISH analysis using a colorimetric antibody-based development system for the DIG labeled probes. In addition, the Instruction y covers each step of the FFPE ISH procedure, including tissue sectioning, recommended selection of microRNA-specific, positive and negative control probes, incubation intervals and temperatures, miRCURY LNA™ microRNA Detection probe concentrations and substrate incubation. The manual further contains a list of recommended equipment and reagents required to establish and optimize microRNA ISH in the lab.

Required probes and reagents

Proper controls and reliable reagents are crucial for allowing all steps of the in situ hybridization procedure to be set up and performed optimally, and thus ensuring successful results. Table A lists the required control probes and reagents for use with the One-day microRNA ISH protocol. The importance of each control is explained in more detail on page 9 with examples in Table B.

Table A. Recommended control probes and reagents for the One-day microRNA ISH protocol.

Probe	Product no.	Purpose
U6 snRNA, hsa/mmu/rno, miRCURY LNA™ microRNA Detection Probe, positive control, 5'-DIG labeled	699002-360 *	Initial optimization of protocol and assessment of sample quality
Positive Control Probe miRCURY LNA™ microRNA Detection Probe, 5'-DIG and 3'-DIG labeled	Select one of Exiqon's wet-lab validated positive control probes (see Table B)	Positive control microRNA known to be expressed in a cell type present in the tissue used. For verification of specific hybridization
Universal Negative Control Probe Scramble-miR, miRCURY LNA™ Detection Probe, negative control, 5'-DIG and 3'-DIG labeled	699004-360 *	Negative control to assess level of background signal from the probe chemistry, e.g. binding to scaffold proteins and cellular matrix
miRCURY LNA™ microRNA Detection Probe, 5'-DIG and 3'-DIG labeled	Select a pre-designed probe targeting your microRNA of interest (6xxxxx-360) or order a custom designed microRNA probe (699998-341)	Detection of your microRNA of interest, double-DIG labeling is recommended for increased sensitivity
microRNA ISH Reagent	**Product no.**	**Purpose**
miRCURY LNA™ microRNA ISH Buffer Set	90000 *	A formamide-free hybridization buffer developed specifically for miRCURY LNA™ microRNA Detection probe-based ISH
Proteinase K, lyophilized	Included in the miRCURY LNA™ microRNA ISH Buffer Set (90000) *	Demasks microRNAs allowing probes to hybridize. Optimized treatment is essential to enable retention of the microRNA target

*This product is also supplied with the miRCURY LNA™ microRNA ISH Optimization Kits (product # 90001 – 90009), which may be used.

Shipping and storage

Upon receipt

The miRCURY LNA™ microRNA Detection probes and the miRCURY LNA™ microRNA Detection Buffer Set are shipped at room temperature. Immediately upon receipt, the miRCURY LNA™ microRNA ISH buffer should be stored at 4°C. Store the DIG- and fluorescein-labeled miRCURY LNA™ microRNA Detection probes and Proteinase-K at -20°C or below. Under these conditions the probes are stable for at least 6 months. It is recommended to store the probes in aliquots and to avoid multiple freeze-thaw cycles (see recommendations below). Do not store in frost-free freezer with automatic thaw-freeze.

Before First Use

- Proteinase-K stock: reconstitute to 20 mg/mL by adding 600 µL 10mM Tris-HCl, pH7.5 (RNase-free). Store appropriate aliquots at -20°C.
- DIG- and fluorescein-labeled LNA™ probes: The following options are possible:
  1) The probes may be stored at 4°C if used within 4 weeks.
  2) Prepare aliquots to be stored at -20°C or below and avoid multiple freeze-thaw cycles.
  Example: divide the LNA™ Detection probes into 5µL or 10µL aliquots into non-stick RNase-free tubes.
  3) Prepare pre-diluted probe aliquots to be stored at -20°C or below in the microRNA ISH buffer. This option is only recommended once the optimal probe concentration has been determined. For details of how to make 1x microRNA ISH buffer and how to denature and dilute the probes, please see page 16. On the day of use, thaw the pre-diluted probe to room temperature and apply directly to the sections. Note: Probe concentration must be optimized (see Tip 3, page 25).

See Tip 3

Protocol and equipment considerations

ISH protocols vary extensively due to different equipment set-up and laboratory routines. The One-day microRNA ISH protocol details the process of manual ISH on formalin-fixed and paraffin embedded tissue samples using double-DIG or double-fluorescein labeled miRCURY LNA™ microRNA Detection probes.

For the ISH steps we recommend a hybridization station that allows precise and rapid temperature adjustments, e.g. Dako Hybridizer. The One-day micorRNA ISH protocol is developed using a hybridization station, but if unavailable, conventional hybridization ovens may be used (see details in FAQs on page 30).

For the immunohistochemical steps Exiqon has had good experience with both horizontal humidifying chambers and Shandon's Sequenza Slide Rack systems.

The chromogenic ISH assay is based on the use of DIG- or fluorescein-labeled probes and therefore requires proper detection reagents (e.g. alkaline phosphatase-conjugated anti-DIG and NBT-BCIP substrate for DIG-labeled probes).

Additional reagents and equipment required, not supplied

In addition to the miRCURY LNA™ microRNA Detection probes and miRCURY LNA™ microRNA Detection Buffer Set, a series of reagents as well as equipment are needed to perform the ISH experiments as described in the protocol. The list below includes recommendations for specific products that have been shown to work well with the One-day microRNA ISH protocol (details on how to prepare buffers and reagents can be found on page 14-17):

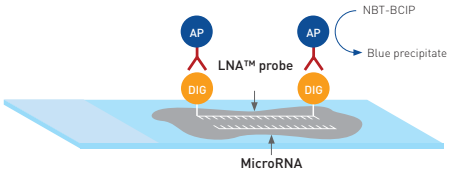
- For DIG-labeled probes: Sheep anti-DIG-AP from Roche (Sigma-Aldrich, Cat. No. 11093274910)
- For fluorescein-labeled probes: Sheep anti-fluorescein-AP from Roche (Sigma-Aldrich, Cat. No. 11426338910)
- Sheep serum (Jackson Immunoresearch, Cat. No. 013-000-121)
- NBT/BCIP ready-to-use tablets (Roche, Cat. No. 11 697 471 001) or equivalent
- Levamisole (Fluka, Cat. No. 31742 or equivalent)
- Syringe and Whatman 1.001-125 filter paper for filtering nuclear counter staining solution
- Nuclear counter stain, Nuclear Fast Red™ (Vector laboratories, Cat. No. H-3403) or equivalent
- Mounting medium, Eukitt® (VWR, Cat. No. 361894G)
- RNaseZap® (Ambion)
- Hybridizer, e.g. Dako Hybridizer, Vysis' ThermoBrite, or Invitrogen's Spotlight Hybridizer
- Humidifying chamber or equivalent for immunohistochemical detection
- Superfrost®Plus slides
- Cover slips
- Slide rack(s) and several glass jars for deparaffinization, dehydration, and washes
- Xylene (for de-paraffination)
- Ethanol (for hydration and dehydration)
- PBS, sterile
- SSC buffer, ultrapure
- M Tris-HCl, pH 7.4
- 0.5M EDTA
- 5M NaCl
- Tween-20 (Sigma, cat no. P1379)
- 30% BSA (Sigma, cat no. A9576)
- For KTBT buffer: Tris-HCl, NaCl and KCl (see page 14)
- Dako Pen (or equivalent hydrophobic PAP pen)
- Non-stick RNase free microfuge tubes
- Sterile filter tips

Experimental background

Overview of the One-day microRNA ISH protocol

The One-day microRNA ISH protocol is designed for detection of microRNA in FFPE tissue sections. The protocol takes advantage of the use of the non-mammalian hapten digoxigenin (DIG) or fluorescein and has been optimized to fit into a one-day experimental set-up. During the protocol the microRNAs are demasked using Proteinase-K, which allows the access of double-DIG or double-fluroscein labeled LNA™ probes to hybridize to the microRNA sequence (Figure 1). The digoxigenin and fluorescein haptens can then be recognized by a specific anti-DIG antibody or anti-fluorescein antibody, respectively, that is directly conjugated with the enzyme Alkaline Phosphatase (AP). AP converts the soluble substrates 4-nitro-blue tetrazolium (NBT) and 5-bromo-4-chloro-3'-indolylphosphate (BCIP) into a water and alcohol insoluble dark-blue NBT-BCIP precipitate. Finally, the nuclear counter stain is applied to the sections to allow better histological resolution.

Figure 1.



The choice between double-DIG and double-fluorescein labeled probes

The One-day microRNA ISH protocol was originally developed for double-DIG labeled LNA™ probes (Jorgensen et al, Methods 2010). However, Exiqon's miRCURY LNA™ Detection probes are available with other label options as well, including 6-carboxyfluorescein (fluorescein) and biotin. The double-fluorescein labeled LNA™ probes show similar staining intensities and signal-to-noise as the double-DIG labeled LNA™ probes. In the One-day microRNA ISH protocol, the fluorescein-labeled probes can therefore easily replace the DIG-labeled probes and have been implemented in the protocol as an alternative to the original DIG-based method. Applicable in general, the concentration of the LNA™ probe (step 4) and the detecting antibody (step 9) should be optimized for best performance (for applications, see e.g. Nielsen et al, Methods Mol Biol 2014 and Knudsen et al, PlosOne 2015).

As described above, detection of the fluorescein label (or hapten) is performed with an alkaline phosphatase (AP)-conjugated anti-fluorescein antibody similarly as performed with the anti-DIG antibody used for detection of the DIG-labeled LNA™ probes. The detecting AP-conjugated anti-fluorescein antibody thus replaces the anti-DIG antibody, and is essentially the only modification in the microRNA ISH protocol.

Optimizing the ISH procedure - the importance of controls (1-3)

In situ hybridization (ISH) is a powerful technique and the most common method for visualizing gene expression and localization in specific tissue and cell types. The technology is far from trivial and is often a very time-consuming and difficult procedure requiring many steps of protocol optimizing to achieve satisfactory ISH results. Detection of microRNA by conventional ISH analysis is no exception. The use of proper controls is crucial in order to limit the time spent on obtaining successful results.

1. LNA™ U6 snRNA control probe

The LNA™ U6 snRNA control probe stains rather easily if the protocol is followed and the sample is intact. This means that the signal can be used for the initial optimization of the protocol parameters by adjustment of Proteinase-K treatment (concentration and duration) and the hybridization temperature (concentration and duration) as well as for testing the quality of the sample.

2. Positive microRNA control probe

The positive control microRNA miRCURY LNA™ Detection probe is used as a control to verify that you are getting a good level of specific signal in the tissue type used. Table B shows a selection of microRNAs which have been experimentally validated at Exiqon to be readily detectable in particular tissues, within a specific cell type. The positive microRNA control is important as it then readily shows that the signal you see is specific and limited to the relevant cells and cell types in the section. Furthermore, the positive microRNA control probe is also important for fine-tuning the Proteinase-K treatment conditions. The U6 snRNA control probe will usually give a robust signal even if Proteinase-K treatment conditions are not fully optimized. Therefore, further fine-tuning might be needed when using the positive microRNA control probe and the actual microRNA probes of interest. See the Troubleshooting section for more information.

3. Negative scramble-miR control

The negative scramble-miR control probe is used once the Proteinase-K treatment is optimized. The probe should give no signal. The negative miRCURY LNA™ microRNA Detection, scramble-miR control probe is designed to not have any targets, so any potential staining gives an idea about the level of background staining (noise). Further optimization might be needed to lower the background staining. See the Troubleshooting section page 24 on "Non-specific staining" for more information.

Table B. Selecting the appropriate positive control microRNA

Positive Control microRNAs	hsa-miR-1-3p	hsa-miR-21-5p	hsa-miR-122-5p	hsa-miR-124-3p	hsa-miR-126-3p	hsa-miR-145-5p	hsa-miR-205-5p	hsa-miR-223-3p
Brain				✓				
Eye				✓	✓			
Muscle	✓				✓			
Lung					✓	✓		
Kidney					✓			
Liver			✓		✓			
Colon					✓	✓		✓
Cervix							✓	
Heart	✓				✓	✓		
Mammary Gland					✓		✓	
Lung cancer		✓			✓	✓	✓	
Colorectal cancer		✓			✓	✓		
Breast cancer		✓			✓	✓	✓	
Kidney cancer		✓			✓	✓		
Cervix cancer		✓			✓	✓	✓	
Testis cancer					✓	✓		
Esophagus cancer								✓
Cell entity	myocyte	varies	hepa-tocyte	neuron	endo-thelial	smooth muscle	basal cells	granu-locyte
Prod No. (for purchasing the miRCURY LNA™ microRNA Detection probe separately)	619868-xxx	619870-xxx	619864-xxx	619867-xxx	619866-xxx	619865-xxx	619873-xxx	619871-xxx
miRCURY LNA™ microRNA ISH Optimization Kit, Prod No.	Kit 1 90001	Kit 2 90002	Kit 3 90003	Kit 4 90004	Kit 5 90005	Kit 7 90007	Kit 8 90008	Kit 9 90009

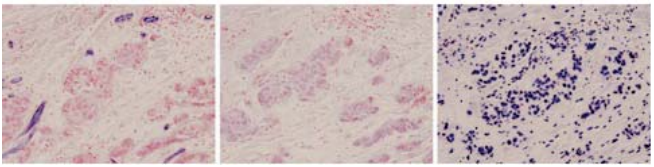
The table displays the tissue(s) in which each of the microRNAs has been experimentally validated at Exqion as a positive control, and in which cell type(s) the microRNA is typically detected. miRCURY LNA™ microRNA Detection probes for each of these positive control microRNAs may be purchased separately, or as part of a miRCURY LNA™ microRNA ISH Optimization Kits.

Optimization of the ISH procedure is divided into three steps:

1. Optimization of the protocol parameters with the miRCURY LNA™ Detection, U6 snRNA control probe (single-DIG or single-fluorescein labeled) by adjustment of hybridization temperature and Proteinase- K treatment. A robust signal obtained with a low concentration of the U6 snRNA probe e.g. 0.1 - 1.0 nM indicates that the sensitivity is in the range suitable for detection of endogenous microRNAs.
2. Control study using the optimized protocol parameters with the miRCURY LNA™ microRNA Detection, positive microRNA control probe and miRCURY LNA™ microRNA Detection, Scramble-miR negative control probe (both double-DIG or double-fluorescein labeled). A strong specific ISH signal should be obtained with minimal background. Further optimization may be required for Proteinase-K treatment and hybridization temperature to minimize background staining.
3. Detection of the microRNA of interest using the appropriate miRCURY LNA™ microRNA Detection probe (double-DIG or double-fluorescein labeled).

Figure 2 shows a typical result of the microRNA ISH procedure. In this case, specific hsa-miR-126-3p ISH signal is seen in endothelial cells, as expected no signal is observed with LNA™ Scramble-miR negative control probe, and overall nuclear staining is seen with LNA™ U6 snRNA positive control probe.

Figure 2. *In situ* hybridization on consecutive sections from FFPE tissue sample with human breast cancer using the miRCURY LNA™ microRNA Detection control probes and miRCURY LNA™ microRNA Detection Buffer Set (FFPE) with the microRNA specific miRCURY LNA™ microRNA Detection probe, hsa-miR-126-3p.



hsa-miR-126-3p, 40nM | Scramble-miR, 40nM | U6 snRNA, 0.1nM

Once optimized, the protocol allows exceptionally clear and specific detection of microRNA at the cellular and partly subcellular level due to high signal-to-noise ratio. An excellent histological resolution is obtained in a wide range of tissue samples. This makes the miRCURY LNA™ microRNA Detection system ideal for a variety of applications ranging from study of microRNA localization, developmental microRNA regulation, examination of functional studies over diagnostic and prognostic biomarker discovery in clinical specimens and other biopsy material. The robustness of the procedure makes it advantageous for both high-throughput ISH analysis as well as individual microRNA localization studies.

Protocol

Before starting the experiment

In order to ensure that the lab, equipment and reagents for the microRNA ISH procedure are in place before starting the experiment, it is recommended to go through the following sequence of steps:

1) Prepare and store probes, ISH buffer and Proteinase-K (page 5).
2) Establish histology lab environment for RNA work (page 13-14).
3) Prepare samples (including fixation of tissue and FFPE preparations, page 14).
4) Cut FFPE sections using Tissue Sectioning Guidelines (page 24).
5) Prepare reagents and buffers (page 14-15).
6) Become confident with the steps in the One-day microRNA ISH protocol (page 18-23).
7) Evaluate appropriate Proteinase-K treatment range for each sample type.
8) Determine ISH sensitivity level using the LNA™ U6 snRNA probe. It may be necessary to repeat Step 6 and 7 to gradually improve the performance of the protocol.
9) Run the microRNA ISH protocol with the LNA™ microRNA probe and LNA™ Scramble-miR probe.
10) Optimize hybridization temperature and probe concentration for each probe.

An overview of the workflow for the One-day microRNA ISH protocol is shown on page 18.

Important note - Cautions for RNA work

RNA work requires specific handling and precautions to prevent RNase contamination of the reagents and degradation of the RNA sample.

Every step in the microRNA ISH procedure including tissue sectioning and DIG-detection, must take place in a clean and nuclease free environment. We recommend that all surfaces are cleaned with RNaseZap®, RNase Away or other RNase removal solution. Wear gloves during the entire process, and only use RNase decontaminated glassware. All buffers and reagents should be prepared using RNase-free water only, e.g. RNase-grade Milli-Q water or DEPC-treated water, and be autoclaved if specified.

FFPE sample requirements and comments on tissue fixation

MicroRNAs are like other RNA fragile molecules sensitive to degradation. Fast and sufficient fixation of tissue specimens is therefore important for successful ISH analyses. For ISH analysis in human specimens, standard overnight fixation in neutral-buffered formalin followed by paraffin embedding often works well. For studies in mouse tissues, perfusion fixation with 4% fresh PFA is recommended before standard overnight fixation in formalin. Consult animal care guidelines before setting up this protocol, see e.g. The Laboratory Mouse by Mark A. Suckow, Peggy Danneman, Cory Brayton (CRC Press) or Pathology of Genetically Engineered Mice by Jerrold Michael Ward, Joel F. Mahler, Robert R. Maronpot (Iowa State University Press). Optimization of the assay performance should preferably be based on analysis of at least 4 FFPE blocks. For detailed guidelines to Tissue Sectioning, please see Tip 1, page 24.

See Tip 1

Glassware

In order to reduce potential RNase contamination of glassware, it is recommended to autoclave all glassware or to heat-treat all glassware for 8 hours at 180°C. Prior to the heat-treatment, it is recommended to wrap all items in aluminum foil, including appropriate stacks of cover slips. Keep apart from untreated glassware.

Preparation of reagents and buffers

In addition to the hybridization buffer and Proteinase-K buffer supplied with the miRCURY LNA™ microRNA ISH Buffer Set, a number of other reagents and buffers need to be prepared prior to initiating the microRNA ISH experiment (see page 7 for a list of recommended materials). Recipes for preparation of required reagents and buffers are listed in Table 1-3.

Please note

Please note that many reagents should be freshly prepared on the day of the experiment or even immediately before use.

Table 1.

Reagents needed during the ISH procedure	
Antibody blocking solution	PBS, 0.1% Tween, 2% Sheep serum, 1% BSA, (see table 3 for details)
Antibody dilutant solution	PBS, 0.05% Tween, 1% sheep serum, 1% BSA (see table 3 for details)
Sheep anti-DIG-AP or anti-fluorescein-AP	See table 3
NBT/BCIP ready-to-use tablets	See table 3
Levamisole	For blocking endogenous AP activity. Prepare a 100 mM stock
Nuclear Fast Red™	Nuclear counter stain

Table 2.

Buffers and stocks to prepare and autoclave* prior to the microRNA ISH experiment	
Proteinase-K buffer	To 900 mL RNase-free water add 5 mL of 1 M Tris-HCl (pH7.4) 2 mL of 0.5 M EDTA 0.2 mL of 5 M NaCl Adjust volume to 1000 mL. Autoclave*.
20xSSC pH 7.0	If purchased as RNase-free then leave as is.
SSC solutions	5xSSC (1 L=250 mL 20xSSC + 750 mL water) 1xSSC (1 L=50 mL 20xSSC + 950 mL water) 0.2xSSC (1 L=10 mL 20xSSC + 990 mL water) Autoclave
PBS-T (0,1%), pH7.4	Add 1 mL of Tween-20 to 1 L of PBS. Autoclave*.
KTBT (AP stop solution)	To 900 mL RNase-free water add 7.9g Tris-HCl (50mM) 8.7g NaCl (150mM) 0.75g KCl (10mM) Adjust volume to 1000mL. Do not adjust pH. Autoclave*.

*autoclave buffers where listed to minimize RNase activity. RNaseAlert® Lab test Kit (Ambion) is an easy and fast test that is recommended for optional testing of potential RNase activity in buffers and reagents.

Table 3.

Reagents to prepare on the day of the experiment				
Proteinase-K reagent	Prepare immediately before use. For a Proteinase-K concentration of 15 µg/mL: Add 7.5 µL Proteinase-K stock to 10 mL Proteinase-K buffer (prepared in Table 2). See further recommendations in Tip 2, page 24.			
Hybridization mix (microRNA ISH buffer and LNA™ Detection probes)	1) Dilute the 2x microRNA ISH buffer 1:1 with RNase-free water, e.g. mix 1 mL 2x microRNA ISH buffer with 1 mL RNAse-free water to give 2 mL 1x microRNA ISH buffer. 2) For each probe to be used in the experiment, place the appropriate amount of LNA™ probe in a 2 mL non-stick RNase-free tube (see table below). 3) Denature the probes at 90°C for 4 minutes. 4) Place the tubes in table-top microfuge and spin down shortly. 5) Immediately add the 2 mL 1x microRNA ISH buffer to each of the tubes with the different LNA™ probes.			
Probe	**Final probe conc.**	**Probe vol.**	**Dilution factor**	**1x microRNA ISH buffer vol.**
LNA™ U6 snRNA (0,5µM)	1 nM	4 µl	1:500	2 ml
LNA™ microRNA probe (25µM)*	20 nM	1,6 µl	1:1250	2 ml
LNA™ microRNA probe (25µM)*	40 nM	3,2 µl	1:625	2 ml
LNA™ Scramble-miR probe (25µM)	40 nM	3,2 µl	1:625	2 ml

* Suggested starting concentrations for microRNA probes can be found in Table 8, page 26.

Antibody blocking and Dilutant solutions	1) To make 10mL blocking and 10mL dilutant solution start with 15mL PBS-T (see table 2) and add 300µL Sheep serum (2% final concentration). Label the tube "Blocking solution" 2) Remove 5 mL from the tube in Step 1, place in a new tube and label "Dilutant solution". 3) To the tube labeled Blocking solution, add 330µl 30% BSA to give a final concentration of 1%. The blocking solution is now ready to use. 4) To the tube labeled Dilutant solution, add 5 mL PBS (to give 0.05%Tween and 1% sheep serum final concentration) and 330µl 30% BSA to give 1% final concentration. The Dilutant solution is now ready for use.
Anti-DIG or anti-fluorescein reagent	Dilute the sheep anti-DIG-AP or anti-fluorescein-AP antibody 1:800 in Antibody Dilutant solution (see above). (Range 1:500-1:2000).
AP substrate	Immediately prior to use, dissolve a NBT-BCIP tablet in Milli-Q water according to the manufacturer's instructions. Add Levamisol to a final concentration of 0.2 mM. Example: if 10 mL AP substrate is prepared, then add 20 µL Levamisol stock. Protect from light before and during incubation.

Please note

left over hybridization mix can be stored at -20°C and will be stable for up to 6 months, avoid multiple freeze-thaw cycles

Workflow overview - One-day microRNA ISH protocol

Below is an overview of the workflow for the microRNA ISH protocol for FFPE samples. The numbers refer to each of the steps in the protocol, see details in the protocol section, page 19-23 The workflow can be followed for both the initial protocol optimization with the LNA™ probes provided with the kit and the subsequent specific microRNA detection.

Process*	Step	Equipment	Time	Temperature
Deparaffination	1	Slide rack and Jars	40 min.	Room Temperature
Proteinase-K	2	Hybridizer	10 min.	37°C
In situ hybridization	4	Hybridizer	60 min.	50-60°C
Stringent washes	6	Water bath	30 min.	50-60°C
Blocking	8	IHC staining racks	15 min.	Room Temperature
Anti-DIG/AP	9		60 min.	
AP reaction	11	IHC staining racks in Oven	120 min.	30°C
Counter stain	14	IHC staining racks	10 min.	Room Temperature
Dehydration	16	Slide rack and Jars	10 min.	
Mounting	17		5 min.	

* PBS washing steps are excluded from the overview. Total time required is 7 hours.

One-day microRNA ISH protocol

The protocol describes every step in the microRNA ISH analysis. When setting up the microRNA ISH experiment for the first time it is recommended to follow the three optimization steps:

1) First, optimize the protocol parameters with the LNA™ U6 snRNA positive control probe by adjustment of hybridization temperature and Proteinase-K treatment.
2) Conduct control study using the optimized protocol parameters with the double-DIG or double-fluorescein LNA™ microRNA positive and negative control probes. Adjust hybridization temperature and Proteinase-K treatment to obtain a strong specific microRNA ISH signal.
3) Finally, detect the microRNA(s) of interest using the appropriate miRCURY LNA™ microRNA Detection probe(s) with the defined protocol parameters keeping in mind that the hybridization temperature may need to be adjusted.

Step 1
Deparaffinize slides in xylene and ethanol

Deparaffinize slides in xylene and ethanol solutions at room temperature (RT) by placing slides with sections in a slide rack, and then move from glass jar to glass jar according to Table 4 ending up in PBS.

Table 4.

Step	Solvent	Duration
1	Xylene	5 min.
2	Xylene	5 min.
3	Xylene	5 min.
4	99.9% Ethanol	Immerse 10 times
5	99.9% Ethanol	Immerse 10 times
6	99.9% Ethanol	5 min.
7	96% Ethanol	Immerse 10 times
8	96% Ethanol	5 min.
9	70% Ethanol	Immerse 10 times
10	70% Ethanol	5 min.
11	PBS	2-5 min.

Step 2 Incubate with Proteinase-K for 10 min. at 37°C	Immediately before use, add Proteinase-K to Proteinase-K buffer (see Table 2 & 3). Place slides on a flat surface and apply approximately 300 µL/slide to fully cover the section and incubate slides for 10 min. at 37°C for example in a Dako Hybridizer. If the Hybridizer is used then remove the humidifying strip inserts. The Proteinase-K concentration range must be optimized for individual tissues (see Tip 2). See Tip 2
Step 3 Place slides in PBS	Place slides into a slide rack inside a jar with PBS, wash twice in PBS.
Step 4 Apply hybridization mix and hybridize for 1 hour at 50-60°C	Place slides on a flat surface and apply 50 µL hybridization mix as prepared in Table 3. For initial protocol optimization, probe concentrations could be: a) 1 nM LNA™ U6 snRNA probe b) 40 nM double-DIG or double-fluorescein LNA™ microRNA probe The probe concentration will need to be optimized for optimal microRNA ISH signal. See Tip 3. Avoid touching the tissue sections with the pipette tip. Then apply a sterile coverslip onto each section, carefully avoiding air bubbles. Place the slides in the Hybridizer (equipped with humidifying strips hymidified with Milli-Q water) and start a program hybridizing for 1 hour. Hybridization temperature must be optimized for individual probes, see Tip 4). See Tip 3+4
Step 5 Disassemble slide and coverslip	Prepare a jar with 5xSSC at RT. One by one, carefully remove the coverslip and immediately place the slide into a slide rack in the 5xSSC buffer. If the coverslips do not easily detach, place the slides directly into the 5xSSC buffer. After a few minutes the coverslips will detach and the slides are transferred into the jar containing 5xSSC.

Step 6
Wash slides in SSC buffers

Wash slides in glass jars according to Table 5. To ensure sufficient stringency perform the washes in glass jars placed in a water bath set to the hybridization temperature.

Table 5.

Step	Buffer	Duration	Temperature
1	5xSSC	5 min.	Hyb temp
2	1xSSC	5 min.	Hyb temp
3	1xSSC	5 min.	Hyb temp
4	0.2xSSC	5 min.	Hyb temp
5	0.2xSSC	5 min.	Hyb temp
6	0.2xSSC	5 min.	RT

Step 7
Apply hydrophobic barrier

Transfer slides to glass jars with PBS.
Apply a hydrophobic barrier around tissue sections using a Dako-Pen following the manufacturer's instructions. Tissue sections are not allowed to dry out during this and the subsequent immunohistochemistry steps. Alternatively, if Shandon Slide Racks are employed, then assemble slides on coverplates using PBS-T.

Step 8
Incubate with blocking solution for 15 min.

Place the slides in a humidifying chamber and incubate 8 with blocking solution for 15 min. at RT. **Important:** Steps 8-15 are carried out in the humidifying chamber or in Shandon Slide Racks.

Step 9
Apply anti-DIG or anti-fluorescein reagent for 60 min.

Remove blocking solution and apply anti-DIG anti-fluorescein reagent depending on which label has been chosen for the LNA™ probes (sheep anti-DIG-AP at 1:800 in antibody dilutant, see Table 3) and incubate for 60 minutes at RT.

Step 10
3x3 min. wash in PBS-T

Wash the slides 3x3 minutes with PBS-T.

Step 11 Incubate with AP substrate for 2 hours at 30°C	Apply freshly prepared AP substrate to the sections (see Table 3) and incubate slides for 2 hours at 30°C in the humidifying chamber. Protect from light during development.
Step 12 Incubate slides in KTBT buffer 2x5 minutes	Incubate slides in KTBT buffer 2x5 minutes to stop the reaction.
Step 13 Wash with water, 2x1 min.	Wash with water, 2x1 minutes.
Step 14 Counter stain with Nuclear Fast Red™	Depending on the size of the tissue, apply 200-300 µL Nuclear Fast Red™ (nuclear counter stain) for 1 minute for nuclear counter staining. Right before application, it is recommended to pass the Nuclear Fast Red™ solution through a paper filter (e.g. Whatman 1.001-125) to remove undissolved color precipitates.
Step 15 Rinse in tap water for 10 min.	Remove slides from the humidifying chamber to a slide rack placed within a glass jar containing tap water. Carefully rinse the slides with running tap water for app. 10 min.

Step 16
Dehydrate slides

Dehydrate slides in ethanol solutions according to Table 6.
Place the slides on clean paper towels.

Table 6.

Step	Solvent	Duration
1	70% Ethanol	Immerse 10 times
2	70% Ethanol	1 min.
3	96% Ethanol	Immerse 10 times
4	96% Ethanol	1 min.
5	99.9% Ethanol	Immerse 10 times
6	99.9% Ethanol	1 min.

Step 17
Mount slides

Mount the slides directly with 1-2 drops of mounting medium (Eukitt®).
Avoid air-drying sections at this step.

Step 18
Microscopy

Allow precipitate to settle overnight and analyze results by light microscopy the subsequent day.

Tips and troubleshooting

Tip 1. Tissue Sectioning Guidelines

It is strongly recommended to wear gloves during paraffin sectioning and in general to maintain an RNase-free environment during all downstream procedures. Use only heat-treated glassware and RNase-free water. Use SuperFrost®Plus slides drawn directly from new packages.

Workstation and Microtome

Before starting the tissue sectioning, the whole workstation (bench top, microtome, blade holder, brushes, tweezers, cooling plate, water bath etc.) needs to cleaned with RNase-Zap/RNase Away.

Cutting sections

1) Prepare a water bath with room temperature RNase-free water and a warm-water bath with RNase-free water at 40-50°C (depending on the paraffin type).
2) Insert a new disposable blade in the knife carrier and place the paraffin block in the cassette clamp. Trim the block in order to avoid the first couple of sections. It is recommended to cool the FFPE blocks on a cooling plate to app. -15°C before cutting to better control the section thickness.
3) Cut 6 µm-thick paraffin sections and place them in the room temperature RNase-free water, where folding can be reversed. Transfer the sections to the heated water bath, where the tissue section is allowed to stretch shortly. It is recommended to mount sections immediately thereafter on electrostatic treated slides, such as SuperFrost®Plus slides, obtained from a new non-contaminated package.
4) Let the paraffin sections dry for 1-2 hours at room temperature and store at 4°C for up to one week. Avoid melting the paraffin until the day prior to the *in situ* hybridization analysis.
5) Melt paraffin in an oven at 60°C for 45 minutes on the day before conducting the ISH experiment. Store slides overnight at 4°C in an RNase-free environment.

Tip 2. Identify appropriate Proteinase-K treatment range

The degree of Proteinase-K treatment depends on fixation and tissue of origin. In general terms, the harder the fixation, the more Proteinase-K is needed, however there are lower and upper limits. For the Proteinase-K treatment step, it is recommended to vary the concentration or the duration, as indicated in Table 7. Optimal (opt) starting values are shown in parenthesis.

To identify the optimal Proteinase-K conditions, start by testing the LNA™ U6 snRNA probe at 4-5 different concentrations between 0.1-2.0 nM using the One-day microRNA ISH Protocol. Once the

conditions have been established, start testing the double-DIG labeled LNA™ microRNA probe (positive microRNA control) and the LNA™ Scramble-miR probe (negative control).

Table 7.

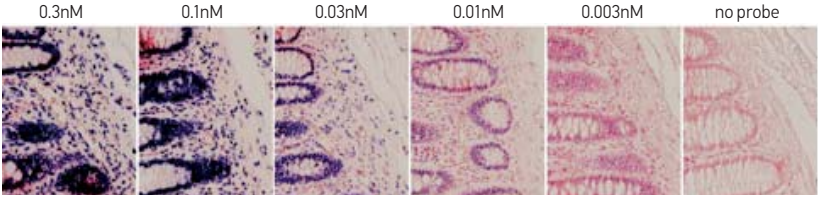
Adjust concentration				
	Fixation	**Temperature**	**Proteinase-K,**	**Duration**
human FFPE	routine formalin	37°C	5-20 µg/mL (15)	10 min.
mouse FFPE	PFA perfusion	37°C	0.5 - 5.0µg/mL (2)	10 min.

Adjust duration				
	Fixation	**Temperature**	**Proteinase-K, conc**	**Duration (opt)**
human FFPE	routine formalin	37°C	15µg/mL	5-30 min. (10)
mouse FFPE	PFA perfusion	37°C	2µg/mL	3-30 min. (10)

Tip 3. Identify ISH sensitivity level

In order to identify the sensitivity of the performance of the ISH protocol, it is recommended to prepare dilutions of the LNA™ U6 snRNA probe. Figure 3 shows that the LNA™ U6 snRNA probe should provide a significant ISH signal at 0.03 to 0.3nM concentration. It is recommended that U6 snRNA ISH signal is intense (as shown for 0.1 nM concentration in Figure 3), when the probe is incubated at 0.1-2.0 nM before moving on with the double-DIG probes for microRNA ISH.

Figure 3. Optimization of positive control probe, LNA™ U6 snRNA, detection signal. On consecutive sections from FFPE tissue sample from normal human colon, the hybridization conditions are optimized by application of increasing concentrations of the postive control probe, LNA™ U6 snRNA positive control.



Once the optimal hybridization conditions are achieved for the LNA™ U6 snRNA probe, it is recommended to use the suggested starting concentrations in Table 8 for the double-DIG labeled miRCURY LNA™ microRNA Detection probes which are also supplied in the microRNA ISH Optimization Kits, (optimal hybridization temperature is in the 50-60°C range).

Table 8. miRCURY LNA™ microRNA Detection probe, suggested concentrations*
(Typical positive microRNA controls, which are also available in the miRCURY LNA™ microRNA ISH Optimization kits)

Probe name	Concentration, nM	RNA T_m
hsa-miR-1-3p	20	81°C
hsa-miR-21-5p	20-40	83°C
hsa-miR-122-5p	40	85°C
hsa-miR-124-3p	40	90°C
hsa-miR-126-3p	40	84°C
hsa-miR-145-5p	20	84°C
hsa-miR-205-5p	20-40	87°C
hsa-miR-223-3p	40	83°C

*optimization range for double-DIG as well as double-fluorescein labeled LNA™ probes could be 20-80 nM.

Tip 4. Identify optimal hybridization temperature

Optimal performance of an ISH probe is related to its signal-to-noise ratio. Oligonucleotide probes, and especially LNA™ containing probes, can potentially hybridize to highly similar sequences if the hybridization temperature is too low. The LNA™ probes typically result in a high signal-to-noise ratio at around 55°C using the One-day microRNA ISH protocol. The positive control LNA™ probes supplied with the microRNA ISH Optimization kit typically result in a high signal-to-noise ratio at 55°C using the One-day microRNA ISH protocol. The LNA™ probes also hybridize at 60°C, but generally provide weaker signals. At 50°C the LNA™ probes give stronger signals, but the risk of cross-hybridization to highly similar sequences (in RNA transcripts or the genome) will increase at low hybridization temperatures.

As a rule-of-thumb, hybridization should be performed at 30°C below the given RNA T_m (or 20°C below DNA T_m).

Troubleshooting

No signal: If no signal is obtained with the LNA™ U6 snRNA probe incubated at 10 nM, it is recommended to ensure that all reagents are prepared according to the recommendations and are RNase free (pages 13 and 15-17). Always test sections from more than one block (a minimum of 4 is recommended).

Not sufficient sensitivity level with the LNA™ U6 snRNA probe. It is recommended that the LNA™ U6 snRNA signal is intense when incubated in the range of 0.1-1 nM. If this is not the case, ensure that the buffers are prepared correctly and that tissue sections are in the range 5-7 µm. Ensure that the AP-reaction takes place at 30°C. Low sensitivity may also be caused by RNase contamination during sectioning or handling during the *in situ* hybridization protocol. Make sure all steps of the ISH protocol are performed in an RNase-free environment. Be aware that both insufficient and hard fixation of tissue samples may result in a low signal. Thus, it is necessary to test several blocks in parallel and avoid concluding on a single sample.

Strong U6 snRNA signal but no or low microRNA signal. If a strong U6 snRNA signal is obtained with 0.1-0.5 nM probe, but no signal is obtained with the supplied positive control LNA™ microRNA probe, it is most likely due to sub-optimal Proteinase-K treatment. Hence, the Proteinase-K concentration or duration of treatment should be optimized (see Tip 2 for details). In order to boost a weak signal, remove the anti-DIG reagent in Step 9 halfway through the incubation (e.g. after 30 minutes) and apply new unused reagent for the second half of the incubation. The same approach can be used for the AP substrate in Step 11. For low copy number targets it may be possible to increase the signal with Tyramide Signal Amplification (TSA) based systems.

Non-specific staining. It is necessary to clarify whether non-specific staining obtained with the LNA™ Scramble-miR probe is related to the DIG-labeled probe itself, the detecting antibody or to endogenous enzymatic reactions. This can be done by a systematic approach where the effect of excluding individual reagents is tested including the DIG-labeled probe, the AP-conjugated anti-DIG or both. If staining is obtained in the absence of AP-conjugated anti-DIG then endogenous AP is present.

If staining is obtained in the absence of the DIG-labeled probe (and no endogenous AP activity is observed) then staining is related to the detecting antibody. If abundant endogenous enzymatic reactivity (e.g. in some intestinal areas and placenta) cannot be prevented by Levamisol, it may require a change to another detection approach, such as TSA-based fluorescence (see e.g. Nielsen and Holmstrøm, Methods Mol. Biol., 2013).

Some non-specific staining can be caused by improperly maintained SSC wash buffer temperatures. It is important to ensure that the SSC wash buffers are preheated to and maintained at the hybridization temperature (see Step 6, page 21).

High background staining. Providing all possibilities for non-specific staining mentioned above have been ruled out and as long as the specific signal from the microRNA probe is strong, high background signal can often be reduced by increasing the hybridization temperature and/or increasing the duration of the stringency washes.

Non-specific staining of ECM. Non-specific staining of extracellular matrix may occur if the concentration of the detecting antibody is too high.

Sections fall off after de-paraffination. Avoid storage of paraffin sections at -20°C. Small and thick sections fall off more easliy than large thin sections. Ensure that the glass slides used have electrostatic properties such as the SuperFrost®Plus slides. When transferring sections from the waterbath to slides it is important to let all excess water drain/evaporate from the section and slide to avoid water or air bubbles getting trapped under the section. For fatty tissues or loose connective tissue e.g. tissue from normal breast, increasing the duration of the melting step from 45 minutes to 60 minutes sometimes helps.

Frequently asked questions

Can I use a hybridization oven instead of a Dako Hybridizer? When using a hybridization oven during the hybridization step, it may be advisable to seal the coverslips using Fixogum. The slides can be placed as such in the hybridization oven without humidifying conditions. However, humidifying conditions may be tried, e.g. by using 1xSSC buffer. In order to establish a more stable hybridization temperature place a metallic plate, e.g. the inserts from a multiblock heater, in the oven. Place the slides on the plate and hybridize for 1–2 hours. Then go to Step 5.

Can I use the protocol for fresh frozen tissue? The protocol can be adapted to cryo sections (Nielsen *et al*., Methods Mol. Biol,. 2014), please find guidelines for fresh frozen samples at www.exiqon.com/mirna-ish-kit. The protocol will require optimization for individual sample types and microRNA targets.

Can I pause the ISH procedure? The individual steps in the One-day microRNA ISH protocol have been optimized to accommodate a One-day protocol. PBS steps may be prolonged, but it is not recommended to extend the protocol to more than one day.

What happens if sections dry out? Sections should be maintained in buffered solutions after the hybridization step. Tissue sections that dry out may cause protein denaturation, which may be particularly harmful to the detecting antibody and its conjugated alkaline phosphatase. This may lower the sensitivity of the assay significantly and in addition cause background staining. Drying out of tissue sections may also reduce the quality of the tissue morphology.

Can I use other detection methods? The DIG labeled LNA™ probes can be detected using alternative methods for DIG detection such as the TSA based systems. The use of alternative systems may necessitate additional steps to be added at various stages of the protocol and requires optimization. Please go to www.exiqon.com/mirna-ish-kit for more information.

Can I detect two different microRNAs in the same section? Two microRNAs can be detected in the same FFPE section by double fluorescence analysis. It may also be possible using double chromogen detection; however, this has not been documented.

For the double microRNA staining assay, two miRCURY LNA™ microRNA Detection probes with different labels (haptens) are required, such as one LNA™ probe double-labeled with DIG and one LNA™ probe double-labeled with fluorescein, or alternatively DIG and Biotin labels (see more details concerning use of double-labeled fluorescein LNA™ probes below, where discussing alternatives to DIG-labeling). Fluorescence detection of microRNAs is performed using peroxidase-conjugated sheep antibodies and Tyramine substrates (TSA), such as TSA-Cy3 (red fluorophore) and TSA-FITC (green fluorophore). ISH can be performed by mixing the two probes. However, if different hybridization temperatures are required for optimal hybridization, or if the two probes interact, hybridization should be performed consecutively. After the two probes have hybridized, one of them is detected with a peroxidase-conjugated antibody (e.g. anti-DIG) followed by incubation with an appropriate TSA substrate (e.g. TSA-FITC). After a peroxidase blocking step (in 3% H2O2), the other probe is detected with the proper peroxidase-conjugated antibody (e.g. anti-FAM) followed by another TSA substrate (e.g. TSA-Cy3). All steps need optimization, including stringent washes and washes in PBS after antibody incubations. The staining intensity should be significant, and should be evaluated against negative control sections in order to adjust for background staining and autofluorescence. The slides can be mounted with DAPI mounting medium.

In the study by Sempere et al. (Clin. Cancer Res. 2010), miR-205 was co-detected with U6 snRNA using double-fluorescein and double-biotin labeled miRCURY LNA™ microRNA Detection probes, respectively. miR-205 and U6 snRNA signals were revealed by sequential TSA reactions with TSA-FITC (green for miR-205 probe) and TSA-rhodamine (red for U6 snRNA probe) substrates.

Can I detect both microRNA and protein in the same section? A microRNA can be detected together with a protein in tissue sections by combined ISH and immunohistochemistry double fluorescence staining. The main limitation in such an assay is the compatibility of pretreatment procedures required for the microRNA probe and the primary antibody. MicroRNA ISH is limited to protease-dependent pretreatment, and therefore some literature searches may be needed to identify an appropriate primary antibody that works well with proteolytic pretreatment. It is recommended to evaluate the performance of the antibody prior to use in the ISH study. Alternative strategies may involve cryo sections, in which microRNA ISH can be performed (Nielsen *et al.*, Methods Mol. Biol., 2014) and most primary antibodies can be applied without pretreatment.

For the combined microRNA ISH and immunohistochemistry, the microRNA in situ hybridization is performed at first, essentially as described in this protocol. The probe is detected with a peroxidase conjugated antibody (e.g. anti-DIG) followed by an appropriate TSA substrate (e.g. TSA-FITC). After stringent washes, the sections are incubated with the primary antibody (e.g. rabbit-anti-cytokeratin) followed by a proper fluorophore-conjugated antibody (e.g. Cy3-conjugated anti rabbit). The One-day microRNA ISH protocol using miRCURY LNA™ microRNA Detection probes has been described in detail by Nielsen and Holmstrøm (Methods Mol. Bio., 2013). The slides can be mounted with DAPI mounting medium.

Can I use other types of double labeling as alternative to double DIG? The original One-day microRNA ISH protocol was developed using DIG-labeled miRCURY LNA™ microRNA Detection probes (Jorgensen et al, Methods, 2010). However, the miRCURY LNA™ microRNA Detection probes can be obtained with other labels as well, including fluorescein and biotin. Detecting AP-conjugated antibodies (anti-fluorescein or anti-biotin), or streptavidin for biotin, must then replace the anti-DIG antibody. The double fluorescein-labeled LNA™ probes show the same signal-to-noise as the double DIG-labeled LNA™ probes and can be used equally well. Thus the One-day microRNA ISH protocol can easily be adapted to use with fluorescein-labeled LNA™ as it is also described in the present procol, where fluorescein-labeled LNA™ probes are introduced as an equally interachangable alternative to double-DIG labels LNA™ probes. The concentration of the miRCURY LNA™ microRNA Detection probe and the detecting antibodies should always be optimized for best performance regardless the choice of label type.

The use of fluorescein probes in microRNA ISH introduces new interesting ISH applications. The carboxyfluorescein (FAM, here referred to as fluorescein) moiety is a fluorophore like fluorescein isothiocyanate (FITC). The fluorescence emission from a double-fluorescein labeled LNA™ probe is not sufficient for visualizing the bound probe itself in standard epifluorescence microscopy, however, the double-fluorescein labeled LNA™ probes have at least two valuable applications. Firstly, because antibodies can be raised against the fluorescein molecule, double fluorescein-labeled LNA™ probes can replace double-DIG labeled LNA™ probes in the standard microRNA ISH protocol, as described above. Secondly, the double-fluoresein labeled LNA™ probes can be used in double ISH assays, where one microRNA is detected with a double-fluoresein labeled LNA™ probe and the other microRNA is detected with a double-DIG labeled LNA™ probe . A derived application hereof is the combined ISH detection of two different RNA targets performed with the two differently labeled LNA™ probes, respectively.

Related products

Exiqon offers a broad variety of products enabling new discoveries concerning the isolation, expression, function and spatial distribution of microRNAs:

miRCURY LNA™ microRNA Detection Probes
For *in situ* hybridization and northern blotting of all annotated microRNAs.

miRCURY LNA™ microRNA ISH Buffer Set
Hybridation buffer and Proteinase K for continuation of the optimized ISH procedure with miRCURY LNA™ microRNA Detecion probes.

miRCURY LNA™ microRNA ISH Optimization kit (FFPE)
Complete kit with control probes and hybridization buffer for easy set up of microRNA in situ hybridization.

miRCURY™ RNA Isolation Kits
Get high quality total RNA suitable for miRCURY LNA™ microRNA Array analysis in as little as 20 minutes. Protocols are available for a large number of sample types and organisms.

miRCURY LNA™ microRNA Array System
miRCURY LNA™ microRNA Arrays for global microRNA expression profiling, complete with all required reagents and Hi-Power Labeling Kits.

miRCURY LNA™ Universal RT microRNA PCR
Exiqon's microRNA qPCR system offers the best available combination of performance and ease-of-use on the microRNA real-time PCR market. The combination of a Universal RT reaction and LNA™-enhanced PCR primers results in unmatched sensitivity and specifi city. The Ready-to-use microRNA PCR panels enable fast and easy microRNA expression profiling. Pre-validated individual assays and custom assays are also available.

miRCURY LNA™ microRNA Inhibitors and Power Inhibitors
Unravel the function of microRNAs by microRNA inhibition. Sophisticated LNA™ design ensures potent inhibition of all microRNAs regardless of their GC content. Chemically modified, highly stable Power Inhibitors for unrivalled potency.

miRCURY LNA™ microRNA Inhibitor Library
For genome-wide high throughput screening of microRNA function.

miRCURY LNA™ microRNA Mimics
Highly potent mature LNA™-enhanced microRNA mimics with unique triple RNA strand design.

miRCURY LNA™ microRNA Target Site Blockers
High-affinity LNA™-enhanced microRNA target site blockers (TSBs) for the study of single microRNA target sites.

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- www.exiqon.com

Literature citations

Please refer to miRCURY LNA™ microRNA Detection probes and ISH Optimization kit when describing a procedure for publication using this product or to the following article: Robust One-day *in situ* hybridization protocol for detection of microRNA in paraffin samples using LNA™ probes. Jørgensen S, Baker A, Møller S, Nielsen BS. Methods (2010), 52,373-381.

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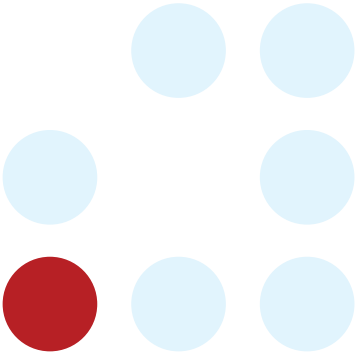

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