



AmoyDx[®] NRAS Mutation Detection Kit

Instructions for Use

REF	8.01.0027	8 tests/kit	For Stratagene Mx3000P™, ABI7500
REF	8.01.0028	8 tests/kit	For LightCycler480, Bio-Rad CFX96
REF	8.01.0029	8 tests/kit	For SLAN-96S



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Background

The *RAS* proto-oncogenes (*HRAS*, *KRAS* and *NRAS*) encode a family of GDP/GTP-regulated switches that convey extracellular signals to regulate the growth and survival properties of cells. GTP-bound RAS transmits its signal through downstream EGFR signaling pathways, for example the RAF→MEK→ERK and PI3K→AKT cascades. *RAS* family members are frequently found in their mutated, oncogenic forms in human tumors. In total, activating mutations in the *NRAS* genes occur in 13~25% of cutaneous melanomas, 1~6% of colorectal cancer and 1% of lung cancer, mainly in exons 2, 3 or 4. The mutation status of *NRAS* gene is relevant to drug resistance of colorectal cancers treated with anti-*EGFR* monoclonal antibodies. As a result, *NRAS* mutations detection supplies evidence for targeted clinical therapy of tumor patients, decreases cost and time of treatment.

Intended Use

The AmoyDx® *NRAS* Mutation Detection Kit is a real-time PCR assay for qualitative detection of 16 somatic mutations in codons 12, 13, 59, 61, 117 and 146 of *NRAS* gene in human genomic DNA extracted from formalin-fixed paraffin-embedded (FFPE) tumor tissue. The kit is intended to assess *NRAS* mutation status in colorectal cancer patients.

The kit is for *in vitro* diagnostic use, and intended to be used by trained professionals in a laboratory environment.

Principles of the Procedure

The kit adopts amplification refractory mutation system (ARMS) technology which comprises specific primers and fluorescent probes to detect gene mutations in real-time PCR assay. During the nucleic acid amplification, the targeted mutant DNA is matched with the bases at the 3' end of the primer, amplified selectively and efficiently, then the mutant amplicon is detected by fluorescent probes labeled with FAM. While the wild-type DNA cannot be matched with specific primers, there is no amplification occurring.

This kit is composed of eight reaction mixes (*NRAS* Reaction Mix 1~7 and *NRAS* External Control Reaction Mix), sufficient Enzyme Mix and Positive Control.

- 1) The ***NRAS* Reaction Mix 1~7** includes a mutation detection system and an internal control system. The mutation detection system includes primers and FAM-labeled probes specific for designated *NRAS* mutations, which is used to detect the *NRAS* mutation status. The internal control system contains primers and HEX-labeled probe for a region of a region of genomic DNA adjacent to the *NRAS* gene, which is used to detect the presence of inhibitors and monitor the accuracy of the experimental operation.
- 2) The ***NRAS* External Control Reaction Mix** contains primers and FAM-labeled probe for a region of genomic DNA adjacent to the *NRAS* gene, which is used to assess the quality of DNA.
- 3) The ***NRAS* Positive Control (PC)** contains a recombinant *NRAS* gene with the 16 mutations.
- 4) The ***NRAS* Enzyme Mix** contains the Taq DNA polymerase for PCR amplification and uracil-N-glycosylase which works at room temperature to prevent PCR amplicon carryover contamination.

Kit Contents

This kit contains the following materials:

Table 1 Kit Contents

Content	Main Ingredients	Quantity
<i>NRAS</i> Reaction Mix	8-tube strip*	12 strips
<i>NRAS</i> Enzyme Mix	Taq DNA Polymerase, Uracil-N-Glycosylase	45µL/tube ×1
<i>NRAS</i> Positive Control	Plasmid DNA	250 µL/tube ×1

* Each 8-tube strip is for testing one sample or one control (Table 2).

Table 2 Information of the 8-tube strip

Tube No.	Reagent	Main Ingredients	Quantity	Fluorescent Signal
①	NRAS Reaction Mix 1	Primers, Probes, Mg ²⁺ , dNTPs	35 μL	FAM, HEX/VIC
②	NRAS Reaction Mix 2	Primers, Probes, Mg ²⁺ , dNTPs	35 μL	FAM, HEX/VIC
③	NRAS Reaction Mix 3	Primers, Probes, Mg ²⁺ , dNTPs	35 μL	FAM, HEX/VIC
④	NRAS Reaction Mix 4	Primers, Probes, Mg ²⁺ , dNTPs	35 μL	FAM, HEX/VIC
⑤	NRAS Reaction Mix 5	Primers, Probes, Mg ²⁺ , dNTPs	35 μL	FAM, HEX/VIC
⑥	NRAS Reaction Mix 6	Primers, Probes, Mg ²⁺ , dNTPs	35 μL	FAM, HEX/VIC
⑦	NRAS Reaction Mix 7	Primers, Probes, Mg ²⁺ , dNTPs	35 μL	FAM, HEX/VIC
⑧	NRAS External Control Reaction Mix	Primers, Probes, Mg ²⁺ , dNTPs	35 μL	FAM

Note:

Distinguish Tube ⑧ from Tube ① according to the hole position at the strip edge, described as follows.



Storage and Stability

The kit requires shipment on frozen ice packs. All components of the kit should be stored immediately upon receipt at -20±5°C and protected from light.

The shelf-life of the kit is eight months. The maximal number of freeze-thaw cycles is five.

Additional Reagents and Equipment Required but Not Supplied

- 1) Compatible PCR instruments:
Stratagene Mx3000P™, ABI7500, LightCycler480, Bio-Rad CFX96 or SLAN-96S.
- 2) DNA extraction kit. We recommend to use AmoyDx DNA extraction kit (AmoyDx® FFPE DNA Kit) for paraffin embedded tissue specimens.
- 3) Spectrophotometer for measuring DNA concentration.
- 4) Mini centrifuge with rotor for centrifuge tubes.
- 5) Mini centrifuge with rotor for PCR tubes.
- 6) Vortexer.
- 7) Nuclease-free centrifuge tubes.
- 8) Adjustable pipettors and filtered pipette tips for handling DNA.
- 9) Tube racks.
- 10) Disposable powder-free gloves.
- 11) Sterile, nuclease-free water.
- 12) 1× TE buffer (pH 8.0)

Precautions and Handling Requirements

For *in vitro* diagnostic use.

Precautions

- Please read the instruction carefully and become familiar with all components of the kit prior to use, and strictly follow the instruction during operation.
- Please check the compatible real-time PCR instruments prior to use.
- DO NOT use the kit or any kit component after their expiry date.
- DO NOT use any other reagents from different lots in the tests.
- DO NOT use any other reagent in the other test kits.

Safety Information

- Handle all specimens and components of the kit as potentially infectious material using safe laboratory procedures.
- As all the chemicals have potential hazard, only trained professionals can use this kit. Please wear suitable lab coat and disposable gloves while handling the reagents.
- Avoid contact of the skin, eyes and mucous membranes with the chemicals. In case of contact, flush with water immediately.
- DO NOT pipet by mouth.

Decontamination and Disposal

- The kit contains positive control; strictly distinguish the positive control from other reagents to avoid contamination which may cause false positive results.
- PCR amplification is extremely sensitive to cross-contamination. The flow of tubes, racks, pipets and other materials used should be from pre-amplification to post-amplification, and never backwards.
- Gloves should be worn and changed frequently when handling samples and reagents to prevent contamination.
- Use separate, dedicated pipettes and filtered pipette tips when handling samples and reagents to prevent exogenous DNA contamination to the reagents.
- Please pack the post-amplification tubes with two disposable gloves and discard properly. DO NOT open the post- amplification PCR tubes.
- All disposable materials are for one time use. DO NOT reuse.
- The unused reagents, used kit, and waste must be disposed of properly.

Cleaning

- After the experiment, wipe down the work area, spray down the pipettes and equipment with 75% ethanol or 10% hypochlorous acid solution.

Instrument Setup

- Setup the reaction volume as 40 μ L
- For Stratagene Mx3000P™, if there is a low net fluorescence signal (dR) but a high background signal (R), please reduce the signal gain setting of the instrument properly.
- For ABI instruments please set up as follows: Reporter Dye: FAM, VIC; Quencher Dye: TAMRA; Passive Reference: NONE.
- For LightCycler480 instrument, please use the Roche 480 adaptor, available from BIOplastics, Cat No. B79480.
- For SLAN-96S, please set up as follows: Probe mode: FAM, VIC. During the result analysis, open the “Preference” window, in “Chart Options” section, select “Selected Wells” for “Y-Axis Scaling Auto-adjust By” and “Absolute Fluorescence Value Normalization” for “Amplification Curve”.
- Refer to the operations manual of the real-time PCR instrument for detailed instructions.
- We recommend that for all PCR instruments in use, a fluorescence calibration should be conducted once a year.

Assay Procedure

1. DNA Extraction

The specimen material must be human genomic DNA extracted from FFPE tumor tissue. DNA extraction reagents are not included in the kit. Before DNA extraction, it is essential to use a standard pathology methodology to ensure tumor sample quality. Carry out the DNA extraction according to the instructions of the DNA extraction kit.

Tumor samples are not homogeneous, they may also contain non-tumor tissue. Data from different tissue sections of the same tumor may be inconsistent. DNA from non-tumor tissue may not contain detectable *NRAS* mutations. It's better to use tumor tissue samples with more than 30% tumor cells.

The OD₂₆₀/OD₂₈₀ value of extracted DNA should be between 1.8 ~ 2.0 (measured using the spectrophotometer, the NanoDrop 1000 /2000 spectrophotometer is recommended).

The amount of extracted DNA from FFPE tissue used for PCR amplification differs according to different storage time (see Table 3).

Table 3 Recommend DNA concentration

Tissue	Storage time	DNA concentration	DNA amount per reaction
FFPE tissue	≤ 3 months	1.5 ng/μL	7.05 ng
	> 3 months & ≤ 1 year	2 ng/μL	9.4 ng
	> 1 year & ≤ 3 years	2.5~3 ng/μL	11.75~14.1 ng

Note:

- The FFPE tissue should be handled and stored properly. The storage time should preferably be less than 3 years.
- The extracted DNA should be used immediately. If not, it should be stored at $-20 \pm 5^{\circ}\text{C}$ for no more than 6 months.
- Before detection, dilute the extracted tissue DNA with 1×TE buffer (pH 8.0) to proper concentration. We recommend using at least 5 μL DNA for 10 times dilution, to ensure the accuracy of final concentration.

2. Mutation Detection

- 1) Take the **NRAS PC** and **NRAS Enzyme Mix** out of the kit from the freezer, and other reagents remained in freezer at $-20 \pm 5^{\circ}\text{C}$.
- 2) Thaw the **NRAS Positive Control** at room temperature. When the reagent is completely thawed, mix the reagent thoroughly by vortexing and centrifuge for 5~10 seconds to collect all liquid at the bottom of the tube.
- 3) Centrifuge **NRAS Enzyme Mix** for 5~10 seconds prior to use.
- 4) Take out the sample DNA (see Table 3 for DNA concentration) and nuclease-free water for NTC (No template control).
 - 1) Prepare NTC mixture: pipet 42.3 μL nuclease-free water (NTC) and 2.7 μL **NRAS Enzyme Mix** into one centrifuge tube. Mix them thoroughly by vortexing, and centrifuge for 5~10 seconds.
 - 2) Prepare sample DNA mixture: pipet 42.3 μL each sample DNA and 2.7 μL **NRAS Enzyme Mix** into one centrifuge tube (see Table 3 for DNA concentration). Mix them thoroughly by vortexing, and centrifuge for 5~10 seconds.
 - 3) Prepare positive control (PC) mixture: pipet 42.3 μL **NRAS Positive control** and 2.7 μL **NRAS Enzyme Mix** into one centrifuge tube. Mix them thoroughly by vortexing, and centrifuge for 5~10 seconds.

Note:

- Each PCR run must contain one PC (Positive control) and one No Template Control (NTC).
 - The prepared mixtures should be used immediately, avoid prolonged storage.
 - Due to the viscosity of the enzyme mix, pipet slowly to ensure all mix is completely dispensed from the tip.
 - Pipet enzyme mix by placing the pipet tip just under the liquid surface to avoid the tip being coated in excess enzyme.
- 5) Take out the **NRAS PCR Reaction Mix** (sufficient for samples, PC and NTC) and centrifuge the strips if there are any reagent droplets in the caps of the PCR tubes. Then briefly uncover the caps prior to use.
 - 6) Add 5 μL of prepared NTC mixture to each PCR tube of the NTC strip, and cap the PCR tubes.
 - 7) Add 5 μL of each prepared sample DNA mixture to each PCR tube of the sample strip, and cap the PCR tubes.
 - 8) Add 5 μL of prepared PC mixture to each PCR tube of the PC strip, and cap the PCR tubes.
 - 9) Briefly centrifuge the PCR tubes to collect all liquid at the bottom of each PCR tube.
 - 10) Place the PCR tubes into the real-time PCR instrument. A recommended plate layout is shown in Table 4.

Table 4 Recommended PCR Plate Layout

Tube	1	2	3	...	8	9	10	11	12
①	Sample1	Sample2	Sample3	...	Sample8	Sample9	Sample10	PC	NTC
②	Sample1	Sample2	Sample3	...	Sample8	Sample9	Sample10	PC	NTC
③	Sample1	Sample2	Sample3	...	Sample8	Sample9	Sample10	PC	NTC
④	Sample1	Sample2	Sample3	...	Sample8	Sample9	Sample10	PC	NTC
⑤	Sample1	Sample2	Sample3	...	Sample8	Sample9	Sample10	PC	NTC
⑥	Sample1	Sample2	Sample3	...	Sample8	Sample9	Sample10	PC	NTC
⑦	Sample1	Sample2	Sample3	...	Sample8	Sample9	Sample10	PC	NTC
⑧	Sample1	Sample2	Sample3	...	Sample8	Sample9	Sample10	PC	NTC

- 11) Setup the PCR Protocol using the cycling parameters in Table 5.

Table 5 Cycling Parameters

Stage	Cycles	Temperature	Time	Data collection
1	1	95°C	5min	/
		95°C	25s	/
		64°C	20s	/
2	15	72°C	20s	/
		93°C	25s	/
		60°C	35s	FAM and HEX/VIC
3	31	72°C	20s	/

- 12) Start the PCR run immediately.
- 13) When the PCR run is finished, analyze the data according to the “Results Interpretation” procedures.

3. Results Interpretation

Before analysis of the mutation data, the following items should be checked:

- 1) For NTC: The FAM Ct values of Tubes ①~⑦ should be ≥ 31 . If not, the data is *INVALID*. The sample should be retested.
- 2) For PC: The FAM Ct values of Tubes ①~⑧ and HEX/VIC Ct values of Tubes ①~⑦ should be < 20 . If not, the data is *INVALID*. The sample should be retested.
- 3) For the internal control assay in Tubes ①~⑦ for each sample: The HEX/VIC Ct values of Tubes ①~⑦ should be < 31 . If not, check the FAM signals of Tubes ①~⑦ :
 - a) If mutant FAM Ct value is < 31 , continue with the analysis.
 - b) If mutant FAM Ct value is ≥ 31 , the data is *INVALID*. The sample should be retested.
- 4) For the external control assay in Tube ⑧ for each sample:
 - a) The FAM Ct value should be between 15~21.
 - b) If the FAM Ct value is < 15 , this indicates the DNA is overloaded. The DNA amount should be reduced and retested. But if the FAM Ct values of Tubes ①~⑦ are in Negative Ct range (see Table 6), the sample is determined as negative.
 - c) If the FAM Ct value is > 21 , this indicates the DNA degradation or the presence of PCR inhibitors, or any error in experimental operation. The sample should be retested with increased or re-extracted DNA. But if any FAM Ct value of tubes ①~⑦ is < 26 , the sample is determined as positive.

Analyze the mutation assay for each sample:

- 5) Record the mutant FAM Ct values of Tubes ①~⑦ for each sample.
- 6) Check the mutant FAM Ct values of Tubes ①~⑦ according to Table 6:

Table 6 Results Determination

Tube No.	①	②	③	④	⑤	⑥	⑦	Results
Optimal Ct range	Ct < 26	Ct < 26	Ct < 26	Ct < 26	Ct < 26	Ct < 26	Ct < 26	Positive.
Acceptable Ct range	$26 \leq \text{Ct} < 28$	$26 \leq \text{Ct} < 29$	$26 \leq \text{Ct} < 29$	$26 \leq \text{Ct} < 29$	$26 \leq \text{Ct} < 28$	$26 \leq \text{Ct} < 29$	$26 \leq \text{Ct} < 29$	Interpret the results according to the ΔCt value.
Cut-off ΔCt value	9	10	10	11	9	11	9	
Negative Ct range	Ct ≥ 28	Ct ≥ 29	Ct ≥ 29	Ct ≥ 29	Ct ≥ 28	Ct ≥ 29	Ct ≥ 29	Negative or under the LOD*.

* LOD: limit of detection

- a) If any FAM Ct value of Tube ①~⑦ is < 26 , the sample is determined as positive (*NRAS* mutation detected).
- b) If any FAM Ct value of Tube ①~⑦ is in Acceptable Ct range, calculate the ΔCt value for each mutation showing positive amplification.
 - i. $\Delta\text{Ct value} = \text{Mutant FAM Ct value} - \text{External control FAM Ct value}$.
 - ii. If the ΔCt value is less than the corresponding cut-off ΔCt value, the sample is determined as positive (Mutation detected).
 - iii. If the ΔCt value is equal or more than the corresponding cut-off ΔCt value, the sample is determined as negative (No mutation detected) or under the LOD of the kit.

- c) If all the FAM Ct values of Tubes ①~⑦ are in Negative Ct range or there is no amplification, the sample is determined as negative (No mutation detected) or under the LOD (Limit of Detection) of the kit.

Performance Characteristics

The performance characteristics of this kit were validated on Stratagene Mx3000PTM, ABI7500, LightCycler480, Bio-Rad CFX96, and SLAN-96S.

1) Limit of Detection:

The limit of detection was established by testing plasmids with 16 *NRAS* mutations. The kit allows detection of 1% mutant DNA in a background of 99% normal DNA at 10 ng sample DNA amount. Except: the sensitivity of *NRAS*-M1, *NRAS*-M2 and *NRAS*-M12 on LightCycler480 and Bio-Rad CFX96 are 2% at 10 ng sample DNA amount.

2) Specificity:

Specificity of the kit was established by testing negative reference controls. The test gave negative results and negative concordance rate was 100%.

3) Accuracy:

The accuracy of the kit was established by testing positive reference controls. The test gave positive results and positive concordance rate was 100%.

4) Interfering substance:

4 common interference substances: hemoglobin, triglyceride, *mycobacterium tuberculosis* and *streptococcus pneumonia* that are easily present in FFPE samples, were evaluated in this study. It is confirmed that the potential maximum concentrations: 2 mg/mL hemoglobin, 37 mmol/L triglyceride 10⁶ CFU/mL *mycobacterium tuberculosis* and 10⁶ CFU/mL *streptococcus pneumonia* would not interfere with the test result.

5) Precision:

3 precision controls: negative control, weak positive control (the mutant content is 5%) and strong positive control (the mutant content is 50%) were used in the validation. 3 batches of the kits were tested with the precision controls by 2 operators twice a day for 20 days on different PCR instruments. The Ct values were calculated, the CV values were all within 10%.

Limitations

- 1) The kit is to be used only by personnel specially trained with PCR techniques.
- 2) The results can be used to assist clinical diagnosis, combined with other clinical and laboratory findings.
- 3) The kit has been validated for use with FFPE tumor tissue DNA.
- 4) The kit can only detect the 16 *NRAS* mutations listed in the appendix.
- 5) Reliable results are dependent on proper sample processing, transport, and storage.
- 6) The sample containing degraded DNA may affect the ability of the test to detect *NRAS* mutation.
- 7) Samples with negative result (No mutation detected) may harbor *NRAS* mutations not detected by this assay.

References

- 1) Brose MS, Volpe P, Feldman M, et al. BRAF and RAS Mutations in Human Lung Cancer and Melanoma. *Cancer Res.*2002,62:6997-7000.
- 2) Ascierto PA, Schadendorf D, Berking C, et al. MEK162 for patients with advanced melanoma harbouring NRAS or Val600 BRAF mutations: a non-randomised, open-label phase 2 study. *Lancet Oncol.* 2013, 14: 249–56.
- 3) Kadoaki Ohashi, Lecia V, Sequist, et al. Characteristics of Lung Cancers Harboring NRAS Mutations. *Clin Cancer Res.*2013,19:2584–91.
- 4) Douillard JY, Oliner KS, Siena S, et al. Panitumumab-FOLFOX4 Treatment and RAS Mutations in Colorectal Cancer. *The New England Journal of Medicine.*2013,369 (11):1023-34.

Symbols



Authorized Representative in the European Community



In Vitro Diagnostic Medical Device



Manufacturer



Catalogue Number



Batch Code



Use By



Contains Sufficient for <n> Tests



Temperature Limitation



Consult Instructions For Use



Keep Dry



This Way Up



Fragile, Handle With Care



Keep Away from Sunlight

Appendix

NRAS Mutations Detected by the Kit

Tube No.	Reagent Supplied	Exon	Mutation	Base Change	Cosmic ID	Name
①	NRAS Reaction Mix 1	2	G12D	35G>A	564	NRAS-M3
			G12S	34G>A	563	NRAS-M10
②	NRAS Reaction Mix 2	2	G13D	38G>A	573	NRAS-M4
			G13R	37G>C	569	NRAS-M6
			G12C	34G>T	562	NRAS-M7
			G12V	35G>T	566	NRAS-M9
③	NRAS Reaction Mix 3	2	G12A	35G>C	565	NRAS-M11
			G13V	38G>T	574	NRAS-M14
			A59D	176C>A	253327	NRAS-M15
④	NRAS Reaction Mix 4	3	Q61R	182A>G	584	NRAS-M1
			Q61K	181C>A	580	NRAS-M2
			Q61L	182A>T	583	NRAS-M5
			Q61H	183A>C	586	NRAS-M8
⑤	NRAS Reaction Mix 5	3	K117N	351G>C	\	NRAS-M16
			K117N	351G>T	\	NRAS-M17
⑥	NRAS Reaction Mix 6	4	A146T	436G>A	27174	NRAS-M12