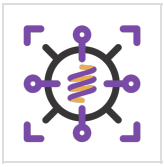

Version 4

Aug 15, 2020

SalivaDirect: RNA extraction-free SARS-CoV-2 diagnostics V.4

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2 Works for me dx.doi.org/10.17504/protocols.io.bjswknfe

Coronavirus Method Development Community

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ABSTRACT

SalivaDirect is an RNA-extraction free, dual-plexed RT-qPCR method for SARS-CoV-2 detection. It can be broadly implemented as it (1) does not require saliva collection tubes containing preservatives, (2) does not require specialized equipment for RNA extraction, and (3) is validated for use with products from multiple vendors. Thus, the simplicity and flexibility of SalivaDirect means that it is not as affected by supply chain bottlenecks as some other assays. Our method is RNA-extraction free which enables testing of low volume and minimally processed saliva in dual-plexed RT-qPCR for SARS-CoV-2 detection. Saliva will be treated with proteinase K followed by a heat inactivation step, and is then directly used as input in the dual-plexed RT-qPCR test. Our aim was not to design new primers and probes for RT-qPCR testing, but rather to use validated primer and probe sets (N1 and RP) developed by the US CDC. The human Ribonuclease P (RP) probe was modified with a different fluorophore so that the primer/probe set could be combined in a dualplex assay, reducing the number of tests to 1 assay with 2 sets.

Version 2 includes:
- Optimized thermocycler conditions
- Locally validated alternative options for Proteinase K, RT-qPCR master mix, and thermocyclers
- Use of 8-strip tubes for sample processing step, due to contamination issues in 96-well plates.

Version 3 has been updated to remove steps for sample self-collection.

Version 4 has updated Ct thresholds for the ABI 7500 Fast Dx.

EXTERNAL LINK

https://covidtrackerct.com/about-salivadirect/

DOI

dx.doi.org/10.17504/protocols.io.bjswknfe

PROTOCOL CITATION

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KEYWORDS

SARS-CoV-2, COVID-19, saliva, extraction-free PCR, COVID-19 diagnostics

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MATERIALS TEXT

Sample collection

- Wide-mouth collection tube/container labelled with unique subject identity number and collection data.
  For example: 5 ml screw cap tube, 25 ml conical tube, 50 mL Falcon tube.

15 mL conical tubes are not recommended due to their long, narrow opening. This design increases the risk of contaminating pipettes when aliquoting the collected sample.
Urine cups can also be used for sample collection; however, they are difficult to vortex during the processing step, and thus we do not recommend them.

- Personal protective equipment (PPE) for **sample collector**. (at minimum, gloves and face mask)

Extraction-free sample processing

- Thermocycler or real-time PCR (qPCR) instrument
- Vortex mixer
- Plate centrifuge or spinner
- Pipette (P20 and P200)
- Pipette tips (20 µL and 200 µL)
- 8-strip PCR tubes (200 µL capacity)
- Proteinase K (volumes for different concentrations given in text)
  ThermoFisher
  NEB
  AmericanBio
- Saliva samples (see “sample collection”)

SARS-CoV-2 RNA Detection by Dual-Plex RT-qPCR

- Real-time PCR (qPCR) instrument. Validation data are currently available for:
  Bio-Rad CFX96
  ABI 7500 Fast
  ABI 7500 Fast Dx
- RT-qPCR kit. Validation data are currently available for:
  NEB Luna Universal Probe One-Step RT-qPCR kit
  Reliance One-Step Multiplex RT-qPCR Supermix
  TaqPath™ 1-Step RT-qPCR Master Mix
- 96 well optical PCR plate and adhesive film
  For Bio-Rad CFX96: plates and seals
  For ABI 7500 Fast (Dx): plates and seals
- Plate centrifuge or spinner
- 1.5 mL tube centrifuge
- Vortex
- Pipettes (P10, P20, P200, and P1000 - optional P10 multichannel)
- Pipette tips (10 µL, 20 µL, 200 µL, and 1000 µL)
- PCR cooler

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- Adhesive film applicator
- 1.5 mL tubes (clear and LightSafe)
- Nuclease-free water
- 70% ethanol, for cleaning
- Twist synthetic SARS-CoV-2 RNA controls at 100 copies/uL
- Extraction-free saliva samples (see "extraction-free sample processing")
- Primers and probes, as follows.

Target	Primer/probe	Sequence
CDC-N1	2019-nCoV_N1-F	GACCCCAAAATCAG CGAAAT
	2019-nCoV_N1-R	TCTGGTTACTGCCA GTTGAATCTG
	2019-nCoV_N1-P	FAM-ACCCCGCATTACGT TTGGTGGACC-IBFQ
Human RNase P	RP-F	AGATTTGGACCTGC GAGCG
	RP-R	GAGCGGCTGTCTCC ACAAGT
	RP-P	Cy5-TTCTGACCTGAAGG CTCTGCGCG-IBRQ

Stocks can be kept at 100 uM, and will be diluted to working concentrations of 20 uM at the beginning of the RT-qPCR protocol section.

SAFETY WARNINGS

Processing of any sample type which could potentially be positive for SARS-CoV-2 should be conducted in BSL2+ settings. Before starting work with these samples, please contact your local EHS (environment, health and safety) or biosafety office for proper guidance on how to work with these samples in your laboratory.

DISCLAIMER:

BEFORE STARTING

Latest information on SalivaDirect is available here.

The FDA issued Emergency Use Authorization for SalivaDirect on 15 August 2020. To become a designated laboratory to run SalivaDirect contact us at **contact@salivadirect.org**. Describe who you are, your intended use, and what equipment you have so that we can make sure that your system is matched to your protocol. We will work with you to conduct any bridging studies, if needed. You must have a **CLIA-certified lab in the United States**.

While collecting saliva is significantly easier than swabs, saliva samples can be difficult to work with. It is important to follow the sample collection guidelines to ensure that saliva, not sputum, is being collected.

Sample collection

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1 Saliva should be collected with the assistance of a healthcare worker or technician.

2 Before collection, clean hands using alcohol-based sanitizer or soap and water (no fragrances) and don appropriate PPE (at minimum, gloves and a mask).

3 Ensure all collection materials are labelled with the correct identifying information.

3.1 While preparing collection materials, direct the sample provider to begin pooling saliva in their mouth. Saliva production can be stimulated by thinking about food (favorite foods, upcoming meals, etc.) or about the saliva collection itself.

This protocol is intended for the collection of the **normal** saliva that naturally pools into the mouth. **No coughing or sniffing prior to sample collection is required.** Ideally, water should be avoided 10 minutes prior to collection. Other drinks, food, and nasal sprays should be avoided for half an hour before sample collection.

4 Remove the lid of the collection container, and direct the sample provider to gently expel saliva into the container until at least 0.5 mL has been collected.

The total volume measured is to exclude any bubbles.

4.1 Once at least 0.5 mL has been collected, securely replace the lid of the collection container.

4.2 Sterilize the container surface with 70% ethanol or a disinfecting wipe, and place the sample in a secondary container or an appropriately labeled biohazard bag.

4.3 Dispose of gloves, and register the sample collection (including date and time).

5 Transfer the sample at room temperature to the laboratory for sample processing. The virus RNA in saliva remains stable at room temperature for at least 7 days.

6 Store samples at 2-8°C until sample transport or processing (up to 7 days) or at -80°C for longer term storage.

Extraction-free sample processing

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7 Add Proteinase K (see table for volume per sample) to designated 8-strip PCR tubes (200 µL capacity).

Vendor	Concentration	Volume
ThermoFisher Scientific MagMAX™ Viral/Pathogen Proteinase K	50 mg/mL	2.5 µL
New England Biolabs Proteinase K, Molecular Biology Grade	20 mg/mL	6.25 µL
AmericanBio Proteinase K	Lyophilized (add 50 mg per 1 mL of nuclease-free water)	2.5 µL

Results of validation experiments for different Proteinase K options are available here.
Reagent order info: ThermoFisher, NEB, AmericanBio

This work should be completed under BSL-2 conditions, and samples potentially containing SARS-CoV-2 should only be handled in a biosafety cabinet. Please seek guidance from your local biosafety office on specific recommendations for working with samples which could contain SARS-CoV-2.

8 Vortex each saliva sample until homogeneous, and immediately transfer 50 µL saliva to each 8-strip PCR tube containing proteinase K.

8.1 Close the 8-strip tube lids tightly.

8.2 Place the 8-strip tubes in a rack and vortex for 1 minute at 3000-5000 RPM.

8.3 Briefly spin down the rack/tubes using a plate spinner or 8-strip tube microcentrifuge.

If no plate centrifuge or spinner is available, the plate can be gently tapped to get the samples at the bottom of each well.

9 Inactivate the proteinase K by heating samples for 5 minutes at 95°C on a PCR instrument or equivalent thermocycler.

9.1 Briefly spin down the tubes using a plate spinner or 8-strip tube microcentrifuge.

10 Store samples at -80°C or proceed immediately to RT-qPCR testing.

RT-qPCR

11 Prepare 20 uM working stocks of the primers and probes (sequences provided in Materials) by adding 20 µL of 100 uM stock to 80 µL nuclease-free water.

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Briefly vortex and centrifuge reagents before use.
Probes are photosensitive and should be stored in the dark.

11.1 Use the 20 uM working stocks to prepare dualplex primer-probe-water mix containing the following:

Component	Volume (1 reaction)	Volume (100 reactions)
2019-nCoV_N1-F (400 nM/reaction)	0.4 µL	40 µL
2019-nCoV_N1-R (400 nM/reaction)	0.4 µL	40 µL
2019-nCoV_N1-P (200 nM/reaction)	0.2 µL	20 µL
RP-F (150 nM/reaction)	0.15 µL	15 µL
RP-R (150 nM/reaction)	0.15 µL	15 µL
RP-P (200 nM/reaction)	0.2 µL	20 µL
Nuclease-free water	2.5 µL	250 µL

A larger volume of primer-probe-water mix can be prepared in advance, aliquoted in LightSafe microcentrifuge tubes, and stored at -20°C.

12 On ice, prepare a master mix containing the following (account for 10% extra lost during pipetting).

Briefly vortex and centrifuge reagents before use.

Component	NEB Luna	Bio-Rad Reliance	Thermo TaqPath
Master mix	10 µL	5 µL	5 µL
RT	1 µL	-	-
Primer-probe-water mix (see above)	4 µL	4 µL	4 µL
Nuclease-free water	-	6 µL	6 µL

5 µL Proteinase K-treated samples, standards, or controls will be added to each well individually in step 15, for a total 20 µL reaction.
Kit order info:
- NEB Luna Universal Probe One-Step RT-qPCR kit
- Reliance One-Step Multiplex RT-qPCR Supermix
- TaqPath™ 1-Step RT-qPCR Master Mix

Validation data, including demonstrated compatibility between kits and thermocyclers, are available here.

12.1 Place the 96-well PCR plate on the PCR plate cooler, and add 15 µL of mastermix to each designated well.

13 Bring the processed samples and the PCR mastermix plate to a biosafety cabinet.

Most institutions will require samples potentially containing full-length SARS-CoV-2 RNA to be handled in a biosafety cabinet. Please seek guidance from your local biosafety office on specific recommendations for working with samples which could contain full-length SARS-CoV-2 RNA.

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13.1 Add 5 µL of extraction-free saliva sample to each designated well of the mastermix plate. Mix by pipetting, taking care to avoid introducing bubbles.

Extraction-free saliva samples can be added using a multichannel pipette for high-throughput testing.

13.2 Add 5 µL of positive control (Twist synthetic SARS-CoV-2 RNA controls at 100 copies/uL) and no-template control (NTC - water) to designated PCR wells for the controls (1 NTC, and 2 positive controls per plate). Mix by pipetting, taking care to avoid introducing bubbles.

13.3 Seal with a transparent plastic qPCR seal. Centrifuge briefly to remove bubbles, if present.

14 Load the plate into the qPCR machine, and run the following thermocycler conditions:

Step	Temperature	Time
1	52°C	10 min
2	95°C	2 min
3	95°C	10 sec
4	55°C	30 sec
5	Read plate (FAM & Cy5 channels)	
Repeat steps 3-5 for 44 cycles.		

Real-time PCR (qPCR) instruments currently locally validated: Bio-Rad CFX96, ABI 7500 Fast, and ABI 7500 Fast Dx. Validation data, including demonstrated compatibility between kits and thermocyclers, are available here.

15 Report results per the following criteria:

Bio-Rad CFX96 & ABI 7500 Fast			
Output	**Significance**	**RP CT**	**N1 CT**
0	Negative	<35	≥40
1	Invalid	≥35	≥40
2	Positive	any value	<40
ABI 7500 Fast Dx			
Output	**Significance**	**RP CT**	**N1 CT**
0	Negative	<35	≥40
1	Invalid	≥35	≥40
2	Positive	any value	<37

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