

Brilliant® II SYBR® Green QPCR Master Mix

INSTRUCTION MANUAL

Catalog #600828 (single kit)
#600831 (10-pack kit)

Revision A

For In Vitro Use Only
600828-12

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Brilliant® II SYBR® Green QPCR Master Mix

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Brilliant® II SYBR® Green QPCR Master Mix

MATERIALS PROVIDED

Catalog #600828 (single kit), #600831 (10-pack kit)

Materials provided (per kit)	Quantity ^{a,b}
2× Brilliant® II SYBR® Green QPCR Master Mix ^c	2 × 2.5 ml
Reference dye ^d , 1 mM	100 µl

^a Sufficient PCR reagents are provided for four hundred, 25-µl reactions.

^b Quantities listed are for a single kit. For 10-pack kits, each item is provided at 10 times the listed quantity.

^c The master mix contains nucleotide mix GATC.

^d The reference dye is light sensitive and should be kept away from light whenever possible.

STORAGE CONDITIONS

All Components: Upon receipt, store all components at –20°C. Store the 2× master mix at 4°C after thawing. Once thawed, full activity is guaranteed for 6 months.

Note *The SYBR Green I dye and the reference dye are light sensitive and should be kept away from light whenever possible.*

ADDITIONAL MATERIALS REQUIRED

Spectrofluorometric thermal cycler

Nuclease-free PCR-grade water

NOTICE TO PURCHASER

Purchase of this product includes an immunity from suit under patents specified in the product insert to use only the amount purchased for the purchaser's own internal research. No other patent rights are conveyed expressly, by implication, or by estoppel. Further information on purchasing licenses may be obtained by contacting the Director of Licensing, Applied Biosystems, 850 Lincoln Centre Drive, Foster City, California 94404, USA.

SYBR® Green is licensed for research and development only under patents owned by Invitrogen Corporation.

INTRODUCTION

Quantitative PCR is becoming increasingly important for gene expression analysis. Many fluorescent chemistries are used to detect and quantitate gene transcripts. One method for real-time quantitation uses SYBR® Green I, a dye that fluoresces when bound nonspecifically to double-stranded DNA. The fluorescence response may be monitored in a linear fashion as PCR product is generated over a range of PCR cycles. The Brilliant® II SYBR Green QPCR master mix includes the components necessary to carry out QPCR amplifications with SYBR Green detection.* The improved Brilliant II formulation yields higher levels of final fluorescence and earlier Ct values for many genomic DNA and cDNA targets and the master mix format is ideal for high-throughput applications. The Brilliant II master mix has been optimized for a faster two-step cycling protocol that is 25% shorter than the protocol used with the original Brilliant SYBR Green QPCR master mix. The Brilliant II master mix is also ideal for quantification of cDNA in a 2-step QRT-PCR reaction when combined with the AffinityScript™ QPCR cDNA Synthesis Kit.

The Brilliant II SYBR Green QPCR master mix has been optimized for maximum performance on Stratagene's Mx3000P® and Mx3005P® real-time PCR systems and Stratagene's Mx4000® multiplex quantitative PCR system, as well as on the ABI 7900HT real-time PCR instrument. In addition, excellent results have been observed using most other QPCR platforms.

The Brilliant II SYBR Green QPCR master mix includes SureStart® *Taq* DNA polymerase, a modified version of *Taq2000*™ DNA polymerase with hot start capability. SureStart *Taq* DNA polymerase improves PCR amplification reactions by decreasing background from nonspecific amplification and increasing amplification of desired products. Using SureStart *Taq*, hot start is easily incorporated into PCR protocols already optimized with *Taq* DNA polymerase, with little modification of cycling parameters or reaction conditions. A passive reference dye (an optional reaction component) is provided in a separate tube, making the master mix adaptable for many real-time QPCR platforms.

* Primers and template are not included.

SYBR® Green I Dye

The SYBR Green I dye¹ has a high binding affinity to the minor groove of double-stranded DNA (dsDNA). It has an excitation maximum at 497 nm and an emission maximum at 520 nm. In the unbound state the dye exhibits little fluorescence; however, when bound to dsDNA, the fluorescence greatly increases, making it useful for the detection of product accumulation during real-time PCR.

The presence of SYBR Green I allows the user to monitor the accumulation of PCR products in real-time. During denaturation, all DNA becomes single-stranded. At this stage, SYBR Green is free in solution and produces little fluorescence. During the annealing step, the primers will hybridize to the target sequence, resulting in dsDNA to which SYBR Green I can bind. As the PCR primers are extended in the elongation phase, more DNA becomes double-stranded, and a maximum amount of SYBR Green I is bound (see Figure 1). The increase in fluorescence signal intensity depends on the initial concentration of target present in the PCR reaction. An important consideration when using SYBR Green I, however, is that signal can also be generated from nonspecific dsDNA (e.g. primer-dimers and spurious PCR products). The plateau resulting in low Ct values for the samples containing target and high Ct values (or “no Ct” values) for the controls containing no target should be chosen for analysis.

Because SYBR Green fluorescence depends on the presence of dsDNA, the specificity of the reaction is determined entirely by the specificity of the primers. Careful primer design and purification can minimize the effects of any side-reaction products, leading to more reliable DNA quantification. For some applications, HPLC-purified primers may generate better results. During the initial stages of assay optimization, it is recommended that the PCR products are analyzed on a gel to verify that the product of interest is being generated and that there is a correlation between the gel and fluorescence data.

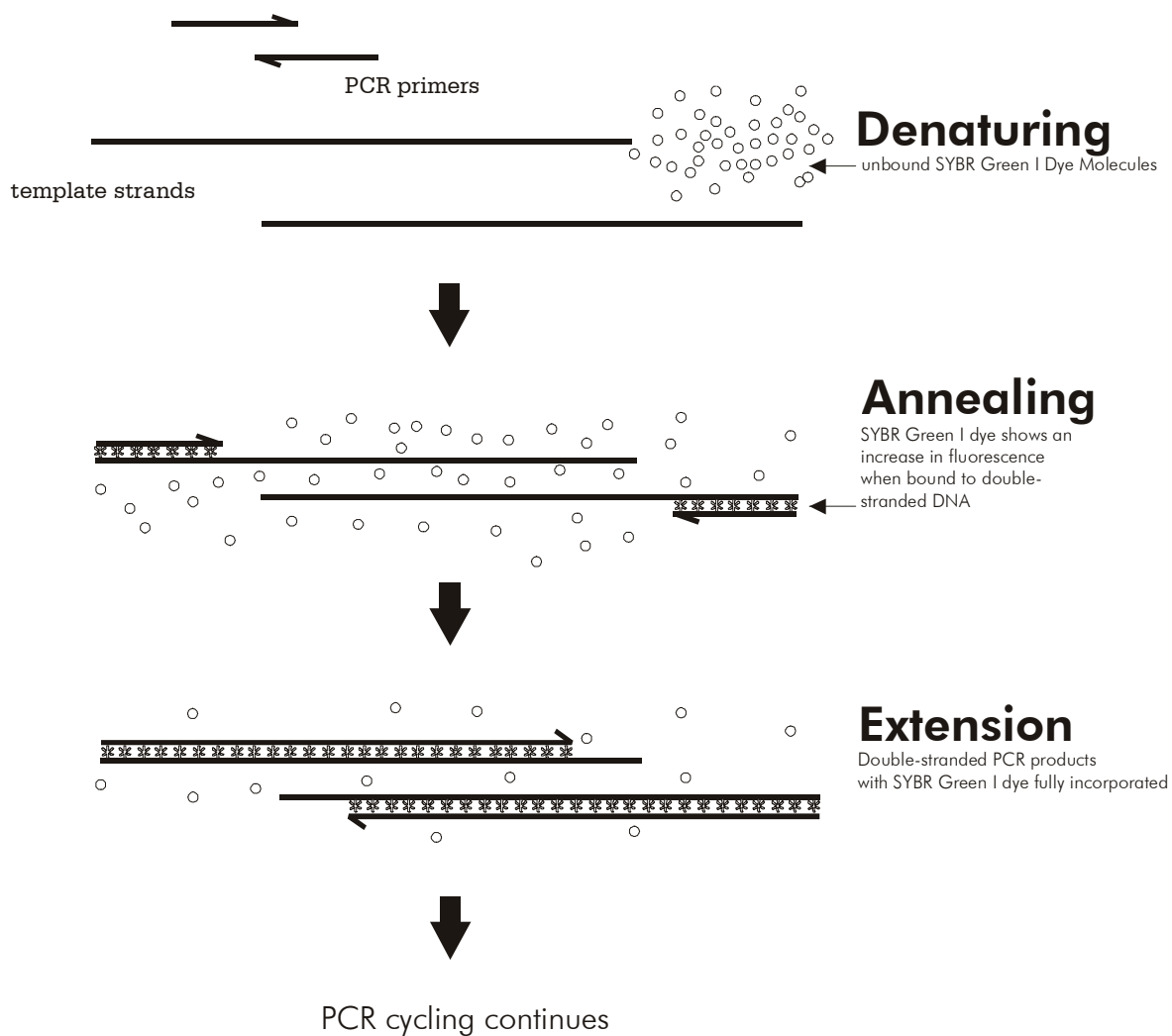


Figure 1 SYBR® Green I dye has a higher affinity for double-stranded DNA (dsDNA) than for single-stranded DNA or RNA. Upon binding dsDNA, the fluorescence yield of SYBR® Green I increases by approximately 1000 fold, making it ideal for detecting the accumulation of dsDNA.

Fluorescence Monitoring in Real-Time

When fluorescence signal from a PCR reaction is monitored in real-time, the results can be displayed as an amplification plot (see Figure 2, top panel), which reflects the change in fluorescence during cycling. Studies have shown that initial copy number can be quantitated during real-time PCR analysis based on threshold cycle (Ct).² Ct is defined as the cycle at which fluorescence is determined to be statistically significant above background (e.g., in Figure 2, the Ct of the “+ template” reaction is 24 and the Ct of the “– template” reaction is 34). The threshold cycle has been shown to be inversely proportional to the log of the initial copy number.² The more template that is initially present, the fewer the number of cycles it takes to get to a point where the fluorescence signal is detectable above background. Quantitative information based on threshold cycle is more accurate than information based on endpoint determinations as it is based on a measurement taken during the exponential phase of PCR amplification when the PCR efficiency has yet to be influenced by limiting reagents, small differences in reaction components, or cycling conditions.

In Figure 2, the Brilliant II SYBR Green QPCR master mix was used in a no-template control reaction and a reaction containing genomic DNA template. In the amplification plot (Figure 2, top panel) the reaction containing template shows a significant increase in fluorescence and has a Ct value of $\cong 24$. The reaction without template has a Ct of 34. To determine if this is true amplification due to template contamination of the reaction or an increase in SYBR Green I fluorescence due to primer-dimer (or some other nonspecific product) formation, a dissociation profile is generated (see Figure 2, bottom panel). In the dissociation curve, PCR samples are subjected to a stepwise increase in temperature from 55°C to 95°C; fluorescence measurements are taken at every temperature increment. After completion of the dissociation segment, fluorescence is plotted versus temperature. For an easy interpretation of the dissociation profile the first derivative should be displayed, i.e. $-R'(T)$ or $-Rn'(T)$. As the temperature increases, the amplification products in each tube will melt according to their composition. If primer-dimer or nonspecific products were made during the amplification step, they will generally melt at a lower temperature (defined as the T_m) than the desired products. The melting of products results in a drop of fluorescence, which is due to SYBR Green dissociation. The dissociation curve plot of these samples shows two fluorescence peaks: one in the “– template” reaction centered around 76°C (which corresponds to primer-dimer); and the other, in the “+ template” reaction, centered around 81°C (which corresponds to amplicon). In this way, the dissociation curve analysis of PCR products amplified in the presence of SYBR Green I dye can be a very powerful tool in the interpretation of fluorescence data. The results obtained from the dissociation plot can also be used for the modification of cycling conditions for future experiments. For example, if a primer-dimer was observed with a T_m of 72°C, the extension step of the PCR can be raised to 74°C, thereby reducing the signal from primer-dimers. This adjustment may not, however, work with all targets, especially long amplicons.

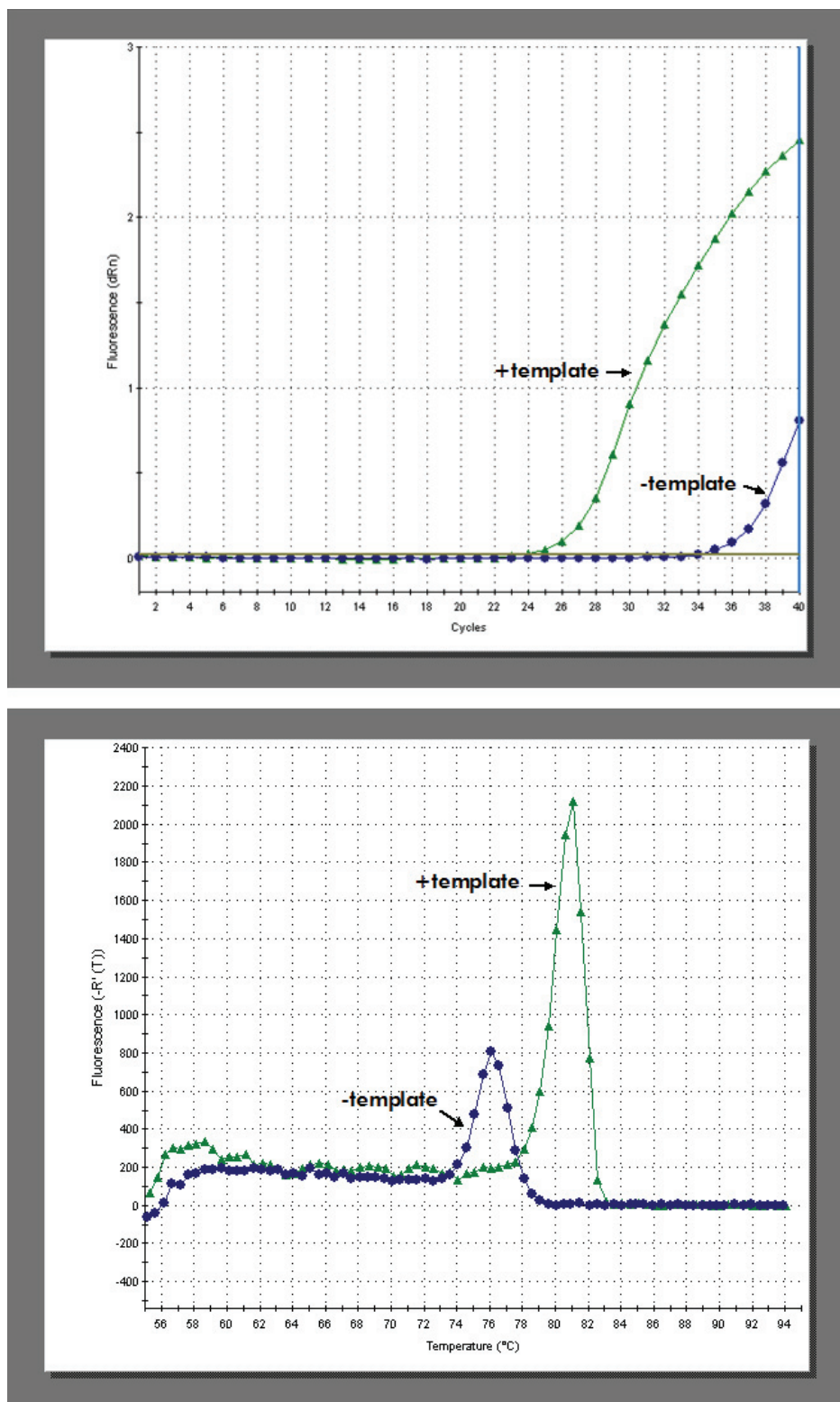


Figure 2 Mx3000P® QPCR instrument amplification plot (top panel) and dissociation curve (bottom panel) of a reaction with and without template DNA. When the amplified products are subjected to dissociation curve analysis, the fluorescence peak corresponding to the amplicon (centered around 81°C) is distinguishable from the peak due to primer-dimer (centered around 76°C).

PREPROTOCOL CONSIDERATIONS

PCR Primers

It is critical in SYBR Green-based QPCR to minimize the formation of non-specific amplification products. This issue becomes more prominent at low target concentrations. Therefore, to maximize the sensitivity of the assay, it is necessary to use the lowest concentration of primers possible without compromising the efficiency of PCR. It is important to consider both the relative concentrations of forward and reverse primers and the total primer concentration. The optimal concentration of the upstream and downstream PCR primers is the lowest concentration that results in the lowest C_t and an adequate fluorescence for a given target concentration, with minimal or no formation of primer-dimer. This concentration should be determined empirically; generally, primer concentrations in the range of 200–600 nM are satisfactory.

Reference Dye

A passive reference dye is included in this kit and may be added to compensate for non-PCR related variations in fluorescence. Fluorescence from the passive reference dye does not change during the course of the PCR reaction but provides a stable baseline to which samples are normalized. In this way, the reference dye compensates for changes in fluorescence between wells caused by slight volume differences in reaction tubes. The excitation and emission wavelengths of the reference dye are 584 nm and 612 nm, respectively. Although addition of the reference dye is optional when using the Mx3005P, Mx3000P or Mx4000 QPCR system, with other instruments (including the ABI 7900HT and ABI PRISM® 7700) the use of the reference dye may be required for optimal results.

Reference Dye Dilution Recommendations

Prepare **fresh*** dilutions of the reference dye prior to setting up the reactions, and **keep all tubes containing the reference dye protected from light as much as possible**. Make initial dilutions of the reference dye using nuclease-free PCR-grade H₂O. If you are using Stratagene's Mx3000P or Mx3005P real-time PCR systems or Mx4000 multiplex quantitative PCR system, use the reference dye at a final concentration of 30 nM. If you are using the ABI 7900HT or the ABI PRISM 7700 instruments, use the reference dye at a final concentration of 300 nM. For other instruments, use the following guidelines for passive reference dye optimization. For instruments that allow excitation at ~584 nm (including most tungsten/halogen lamp-based instruments and instruments equipped with a ~584 nm LED), begin optimization using the reference dye at a final concentration of 30 nM. For instruments that do not allow excitation near 584 nm, (including most laser-based instruments) begin optimization using the reference dye at a final concentration of 300 nM.

* The diluted reference dye, if stored in a light-protected tube at 4°C, can be used within the day for setting up additional assays.

Magnesium Chloride

The optimal MgCl_2 concentration promotes maximal amplification of the specific target amplicon with minimal nonspecific products and primer-dimer formation. High levels of the Mg^{2+} ion tend to favor the formation of nonspecific dsDNA, including primer-dimers. Therefore, when a SYBR Green-based QPCR assay is being optimized, the MgCl_2 levels should be as low as possible, as long as the efficiency of amplification of the specific target is not compromised (typically between 1.5 and 2.5 mM MgCl_2). The Brilliant II SYBR Green QPCR master mix contains MgCl_2 at a concentration of 2.5 mM (in the 1× solution), which is suitable for most targets. The concentration may be increased, if desired, by adding a small amount of a concentrated MgCl_2 solution to the 1× experimental reaction at the time of setup.

Data Acquisition with a Spectrofluorometric Thermal Cycler

The instrument should be set to collect SYBR Green I data in real-time at each cycle. How this is accomplished will depend on the software that commands the particular instrument you are using. Consult the manufacturer's instruction manual for the instrument and software version you are using.

When developing an assay, it is necessary to decide whether to use a 2-step or a 3-step PCR protocol. Stratagene recommends a 2-step protocol for the Brilliant II SYBR Green QPCR master mix, but a 3-step protocol may be helpful when using primers with low melting temperatures. In a 2-step cycling protocol, fluorescence data are collected during the combined annealing/extension step. When using a 3-step protocol, it is prudent to collect fluorescence data at both the annealing step and the extension step of the PCR reaction. For subsequent experiments, the plateau resulting in low Ct values for the samples containing target and high Ct values (or “no Ct” values) for the controls containing no target should be chosen for analysis. For longer amplicons, fluorescence measurements taken during the extension step generally yield more useful data.

Multiplex PCR

Multiplex PCR is the amplification of more than one target in a single polymerase chain reaction.³ Because SYBR Green I dye fluoresces in the presence of any dsDNA, multiplexing with the Brilliant II SYBR Green QPCR master mix is not recommended.

Preventing Template Cross-Contamination

Take precautions to minimize the potential for carryover of nucleic acids from one experiment to the next. Use separate work areas and pipettors for pre- and post-amplification steps. Use positive displacement pipets or aerosol-resistant pipet tips.

PROTOCOL

Preparing the Reactions

Notes *Once the tube containing the Brilliant II SYBR Green QPCR master mix is thawed, store it on ice while setting up the reactions. Following initial thawing of the master mix, store the unused portion at 4°C. Multiple freeze-thaw cycles should be avoided. SYBR Green I dye (present in the master mix) is light-sensitive; solutions containing the master mix should be protected from light whenever possible.*

It is prudent to set up a no-template control reaction to screen for contamination of reagents or false amplification.

1. If the reference dye will be included in the reaction, (optional), dilute the dye solution provided **1:500 (Mx3000P, Mx3005P, and Mx4000 instruments)** or **1:50 (ABI PRISM 7700 and ABI 7900HT instruments)** using nuclease-free PCR-grade H₂O. For other instruments, use the guidelines in the *Reference Dye* section under *Preprotocol Considerations*. **Keep all solutions containing the reference dye protected from light.**

Note *If using a system other than the Mx3000P, Mx3005P or Mx4000 instruments, the use of the reference dye may be required for optimal results.*

2. Prepare the experimental reactions by combining the following components *in order*. Stratagene recommends preparing a single reagent mixture for duplicate experimental reactions and duplicate no-template-controls (plus at least one reaction volume excess), using multiples of each component listed below.

Experimental Reaction

Nuclease-free PCR-grade water to adjust the final volume to 25 µl
(including experimental DNA)

12.5 µl of 2× Brilliant II SYBR Green QPCR master mix

x µl of upstream primer (200–600 nM final concentration)

x µl of downstream primer (200–600 nM final concentration)

0.375 µl of diluted reference dye (optional)

Note *A total reaction volume of 50 µl may also be used.*

3. Gently mix without creating bubbles (do not vortex), then distribute the mixture to the individual experimental reaction tubes.
4. Add *x* µl of experimental gDNA, cDNA, or plasmid DNA to each reaction.

5. Gently mix the reactions without creating bubbles (do not vortex).

Note Bubbles interfere with fluorescence detection.

6. Centrifuge the reactions briefly.

PCR Cycling Programs

7. Place the reactions in the instrument and run one of the PCR programs listed below. Stratagene recommends a two-step cycling protocol for most primer/template systems. For targets <150 bp in length, the fast protocol with two-step cycling may be used to decrease run times without compromising amplification efficiency. For primers with low melting temperatures, the three-step cycling protocol may be optimal.

Recommended Protocol with Two-Step Cycling (All Targets)

Cycles	Duration of cycle	Temperature
1	10 minutes ^a	95°C
40	30 seconds	95°C
	1.0 minute ^b	60°C

^a Initial 10 minute incubation is required to activate the DNA polymerase.

^b Set the temperature cycler to detect and report fluorescence during the annealing/extension step of each cycle.

Fast Protocol with Two-Step Cycling (Targets <150 bp)

Cycles	Duration of cycle	Temperature
1	15 minutes ^a	95°C
40	10 seconds	95°C
	30 seconds ^b	60°C

^a Initial 15 minute incubation is required to activate the DNA polymerase.

^b Set the temperature cycler to detect and report fluorescence during the annealing/extension step of each cycle.

Alternative Protocol with Three-Step Cycling (All Targets)

Cycles	Duration of cycle	Temperature
1	10 minutes ^a	95°C
40	30 seconds	95°C
	1.0 minute ^b	50–60°C ^c
	30 seconds ^b	72°C

^a Initial 10 minute incubation is required to activate the DNA polymerase.

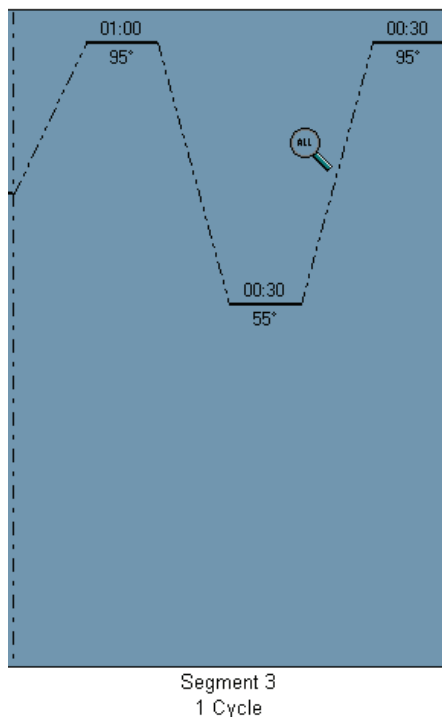
^b Set the temperature cycler to detect and report fluorescence during the annealing and extension step of each cycle.

^c Choose an appropriate annealing temperature for the primer set used.

Dissociation Programs

8. If using Stratagene's Mx3000P, Mx3005P, or Mx4000 instruments, follow the dissociation guidelines below. If using another instrument, follow the manufacturer's guidelines for generating dissociation curves.

Dissociation Program for All Targets (Mx3000P, Mx3005P)



Prior to the dissociation curve, incubate the reactions for 1 minute at 95°C to denature the PCR products. Ramp down to 55°C. For the dissociation curve, ramp up the temperature from 55°C to 95°C (at the instrument default rate of 0.2°C/sec) and collect fluorescence data continuously on the 55–95°C ramp. Figure 3 shows how to set the *Thermal Profile* for the dissociation curve program on the Mx3000P and Mx3005P instruments.

Figure 3 Dissociation program settings on the Mx3000P® and Mx3005P® real-time PCR instruments.

Dissociation Program for All Targets (Mx4000)

Incubate the amplified product for 1 minute at 95°C, ramping down to 55°C at a rate of 0.2°C/sec. For the dissociation curve, complete 81 cycles of incubation where the temperature is increased by 0.5°C/cycle, beginning at 55°C and ending at 95°C. The duration of each cycle should be set to 30 seconds. Figure 4 shows how to correctly set the *Plateau Properties* for the dissociation curve program on the Mx4000 instrument. To access the *Plateau Properties* dialog box for the dissociation curve segment, double-click on the solid line corresponding to the 55° plateau in Segment 4 of the *Thermal Profile Setup* window.

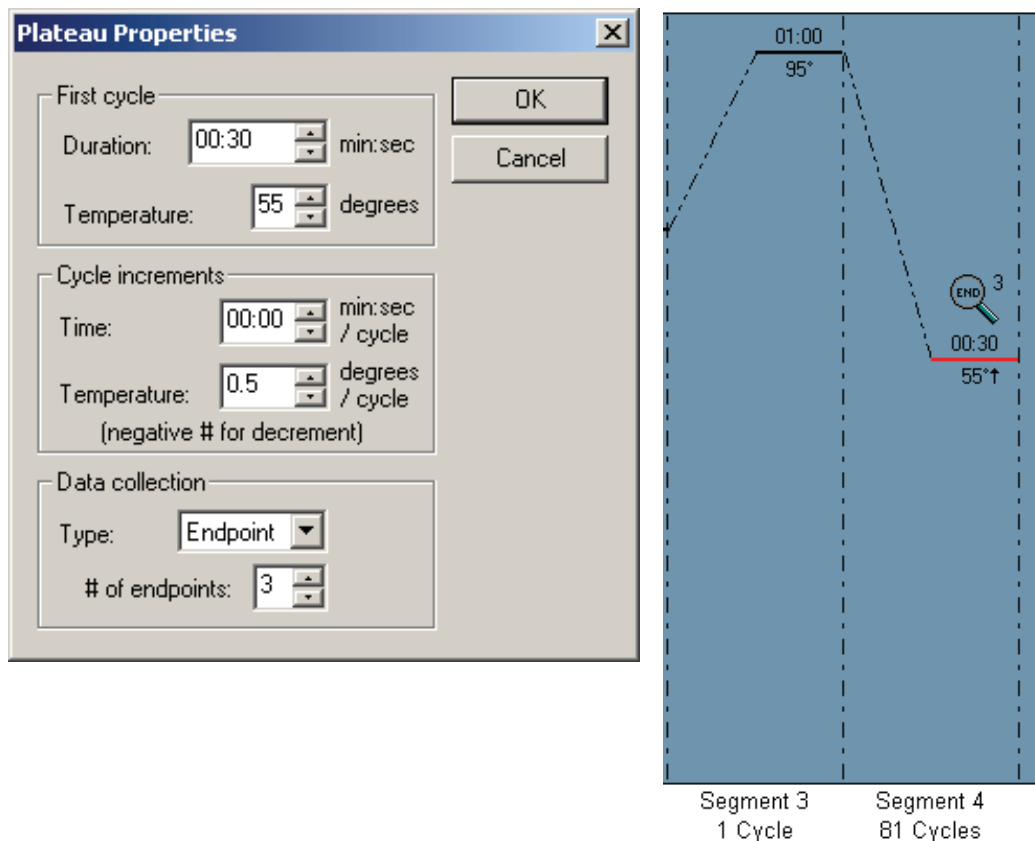


Figure 4 Settings for the dissociation program plateau properties on the Mx4000® multiplex quantitative PCR instrument.

TROUBLESHOOTING

Observation	Suggestion(s)
No (or little) increase in fluorescence with cycling	Optimize the primer concentration.
	Ensure that the correct concentration and amount of template was used and that the template sample is of good quality. If unsure, make new serial dilutions of template before repeating PCR. It may also be possible to check for PCR inhibitors by adding this target into an assay that is known to work.
	Ensure the annealing/extension time (2-step cycling protocol) or extension time (3-step cycling protocol) is sufficient. Check the length of the amplicon and increase the time if necessary.
	Use a sufficient number of cycles in the PCR reaction.
	If using a 3-step cycling protocol, ensure the annealing temperature is appropriate for the primers used.
	Gel analyze PCR product to determine if there was successful amplification.
	Ensure the correct dilution of reference dye was used.
	SureStart Taq DNA polymerase was not activated. Ensure that the 10 minute incubation (15 minute for fast cycling) at 95°C was performed as part of the cycling parameters.
	The MgCl ₂ concentration is not optimal. The MgCl ₂ concentration in the 1 × Brilliant II SYBR Green QPCR master mix is 2.5 mM. It is possible to add small amounts of concentrated MgCl ₂ to the experimental reactions to increase the MgCl ₂ concentration, if desired.
No (or little) increase in fluorescence with long amplicons (> 400 bp)	Increase the length of the annealing/extension step (2-step cycling protocol) or the extension step (3-step cycling protocol).
There is a large abundance of primer-dimer and nonspecific PCR products	Increase the annealing temperature (3-step cycling protocol) above the T _m of the primer-dimer and/or nonspecific products.
	Re-design primers.

REFERENCES

1. Molecular Probes, Inc., at <http://www.probes.com/media/pis/mp07567.pdf>.
2. Higuchi, R., Fockler, C., Dollinger, G. and Watson, R. (1993) *Biotechnology* (N Y) 11(9):1026-30.
3. Edwards, M. and Gibbs, R. (1995). Multiplex PCR. In *PCR Primer: A Laboratory Manual*, C. W. Dieffenbach and G. S. Dveksler (Eds.), pp. 157-171. Cold Spring Harbor Laboratory Press, Plainview, NY.

ENDNOTES

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MSDS INFORMATION

The Material Safety Data Sheet (MSDS) information for Stratagene products is provided on Stratagene's website at <http://www.stratagene.com/MSDS/>. Simply enter the catalog number to retrieve any associated MSDS's in a print-ready format. MSDS documents are not included with product shipments.



BRILLIANT® II SYBR® GREEN QPCR MASTER MIX

Catalog #600828, #600831

QUICK-REFERENCE PROTOCOL

Prior to the experiment, it is prudent to carefully optimize experimental conditions and to include controls at every stage. See *Preprotocol Considerations* for details.

1. If the passive reference dye will be included in the reaction (optional), dilute **1:500** (Mx3000P or Mx4000 instrument) or **1:50** (ABI 7900HT or ABI PRISM 7700 instrument). **Keep all solutions containing the reference dye protected from light.**

Note *If using a system other than the Mx4000, Mx3000P or Mx3005P instruments, the use of the reference dye may be required for optimal results.*

2. Thaw the Brilliant II SYBR Green QPCR master mix and store on ice. Following initial thawing of the master mix, store the unused portion at 4°C.

Note *Multiple freeze-thaw cycles should be avoided. **SYBR Green I dye (present in the master mix) is light-sensitive; solutions containing the master mix should be protected from light whenever possible.***

3. Prepare the experimental reaction by adding the following components *in order*:

Experimental Reaction

Nuclease-free PCR-grade H₂O to adjust the final volume to 25 µl (including experimental DNA)

12.5 µl of 2× Brilliant II SYBR Green QPCR master mix

x µl of upstream primer (200–600 nM final concentration is recommended)

x µl of downstream primer (200–600 nM final concentration is recommended)

0.375 µl of **diluted** reference dye from step 1 (optional)

Note *Total reaction volumes of 50 µl may also be used.*

4. Gently mix the reaction without creating bubbles (**bubbles interfere with fluorescence detection; do not vortex**).
5. Add x µl of experimental gDNA, cDNA, or plasmid DNA to each experimental reaction.
6. Gently mix the reaction without creating bubbles (**do not vortex**).
7. Centrifuge the reaction briefly.

8. Place the reaction in the instrument and run the appropriate PCR program below.

Recommended Protocol with Two-Step Cycling (All Targets)

Cycles	Duration of cycle	Temperature
1	10 minutes ^a	95°C
40	30 seconds	95°C
	1.0 minute ^b	60°C

^a Initial 10 minute incubation is required to activate the DNA polymerase.

^b Set the temperature cycler to detect and report fluorescence during the annealing/extension step of each cycle.

Fast Protocol with Two-Step Cycling (Targets <150 bp)

Cycles	Duration of cycle	Temperature
1	15 minutes ^a	95°C
40	10 seconds	95°C
	30 seconds ^b	60°C

^a Initial 15 minute incubation is required to activate the DNA polymerase.

^b Set the temperature cycler to detect and report fluorescence during the annealing/extension step of each cycle.

Alternative Protocol with Three-Step Cycling (All Targets)

Cycles	Duration of cycle	Temperature
1	10 minutes ^a	95°C
40	30 seconds	95°C
	1.0 minute ^b	50–60°C ^c
	30 seconds ^b	72°C

^a Initial 10 minute incubation is required to activate the DNA polymerase.

^b Set the temperature cycler to detect and report fluorescence during the annealing and extension step of each cycle.

^c Choose an appropriate annealing temperature for the primer set used.

9. Follow the dissociation guidelines below for the instrument used.

Dissociation Program for All Targets (Mx3000P®/Mx3005P® Instruments)

Incubate the reactions for 1 minute at 95°C, ramping down to 55°C. For the dissociation curve, ramp up the temperature from 55°C to 95°C (at the instrument default rate of 0.2°C/sec) and collect fluorescence data continuously on the 55–95°C ramp.

Dissociation Program for All Targets (Mx4000® Instrument)

Incubate the amplified product for 1 minute at 95°C, ramping down to 55°C at a rate of 0.2°C/sec, followed by 81 cycles of incubation where the temperature is increased by 0.5°C/cycle, beginning at 55°C and ending at 95°C. Set the cycle duration to 30 seconds/cycle.

Dissociation Program for All Targets (Other Instruments)

Follow manufacturer's guidelines for setting up dissociation depending on the instrument's software version.