

## Product Information

### TRI Reagent®

For processing tissues, cells cultured in monolayer or cell pellets

Catalog Number **T9424**  
Store at room temperature.

## TECHNICAL BULLETIN

### Product Description

TRI Reagent is a quick and convenient reagent for use in the simultaneous isolation of RNA, DNA, and protein. Successful isolations from human, animal, plant, yeast, bacterial, and viral samples can be obtained. A convenient single-step liquid phase separation results in the simultaneous isolation of RNA, DNA, and protein.<sup>1</sup> This procedure is an improvement of the single-step method reported by Chomczynski and Sacchi<sup>2</sup> for total RNA isolation. TRI Reagent performs well with large or small amounts of tissue or cells and many samples can be simultaneously extracted.

This product, a mixture of guanidine thiocyanate and phenol in a monophasic solution, effectively dissolves DNA, RNA, and protein on homogenization or lysis of tissue sample. After adding chloroform or 1-bromo-3-chloropropane and centrifuging, the mixture separates into 3 phases: an aqueous phase containing the RNA, the interphase containing DNA, and an organic phase containing proteins. Each component can then be isolated after separating the phases. One ml of TRI Reagent is sufficient to isolate RNA, DNA, and protein from 50–100 mg of tissue,  $5\text{--}10 \times 10^6$  cells, or 10 cm<sup>2</sup> of culture dish surface for cells grown in monolayer.

This is one of the most effective methods for isolating total RNA and can be completed in only 1 hour starting with fresh tissue or cells. The procedure is very effective for isolating RNA molecules of all types from 0.1–15 kb in length. The resulting RNA is intact with little or no contaminating DNA and protein. This RNA can be used for Northern blots, mRNA isolation, *in vitro* translation, RNase protection assay, cloning and polymerase chain reaction (PCR).

The DNA is in the interphase and phenol phase, which forms after the addition of chloroform or 1-bromo-3-chloropropane to the TRI Reagent in Sample Preparation, step 2. After precipitation and multiple washes, the DNA is dissolved in 8 mM NaOH. The solution is neutralized and the DNA is ready for analysis. The resulting DNA is suitable for PCR, restriction enzyme digestion, and Southern blotting.

After precipitating the DNA with ethanol (DNA Isolation, step 1), the proteins can be removed from the phenol-ethanol supernatant. The isolated material can be probed for specific proteins by Western blotting.<sup>1</sup>

### Reagents Required but Not Provided

#### RNA Isolation:

- Chloroform, Catalog Number C2432, or 1-Bromo-3-chloropropane, Catalog Number B9673
- 2-Propanol, Catalog Number I9516
- 75% Ethanol
- 1 mM sodium phosphate, Catalog Number S3264, pH 8.2, 0.5% SDS solution, Catalog Number L4522, diluted 20-fold, formamide, or diethylpyrocarbonate-treated water

#### DNA Isolation:

- 8 mM NaOH
- 0.1 M trisodium citrate, 10% ethanol solution
- Absolute ethanol
- 75% ethanol
- EDTA

#### Protein Isolation:

- 2-Propanol, Catalog Number I9516
- Absolute ethanol, Catalog Number E7023
- 95% Ethanol, Catalog Number E7148
- 1% SDS, Catalog Number L4522, diluted 10-fold
- 0.3 M Guanidine hydrochloride, Catalog Number G3272, in 95% ethanol

### Precautions and Disclaimer

This product is for R&D use only, not for drug, household, or other uses. Please consult the Material Safety Data Sheet for information regarding hazards and safe handling practices.

### Storage/Stability

Store the product at room temperature.

### Procedures

#### Sample Preparation

##### 1A. Tissue:

Homogenize tissue samples in TRI Reagent (1 ml per 50–100 mg of tissue) in a Polytron® or other appropriate homogenizer.

**Note:** If minimal shearing of the DNA is desired, use a loosely fitting homogenizer, not a Polytron (see DNA Isolation, step 3, note b). The volume of the tissue should not exceed 10% of the volume of the TRI Reagent.

##### 1B. Monolayer cells:

Lyse cells directly on the culture dish. Use 1 ml of the TRI Reagent per 10 cm<sup>2</sup> of glass culture plate surface area. After addition of the reagent, the cell lysate should be passed several times through a pipette to form a homogenous lysate.

**Note:** TRI Reagent is **not** compatible with plastic culture plates.

##### 1C. Suspension cells:

Isolate cells by centrifugation and then lyse in TRI Reagent by repeated pipetting. One ml of the reagent is sufficient to lyse 5–10 × 10<sup>6</sup> animal, plant, or yeast cells, or 10<sup>7</sup> bacterial cells.

##### Notes:

- If samples have a high content of fat, protein, polysaccharides, or extracellular material such as muscle, fat tissue, and tuberous parts of plants an additional step may be needed. After homogenization, centrifuge the homogenate at 12,000 × g for 10 minutes at 2–8 °C to remove the insoluble material (extracellular membranes, polysaccharides, and high molecular mass DNA). The supernatant contains RNA and protein. If the sample had a high fat content, there will be a layer of fatty material on the surface of the aqueous phase that should be removed. Transfer the clear supernatant to a fresh tube and proceed with step 2. Recover the high molecular mass DNA from the pellet by following DNA Isolation, steps 2 and 3.

- Some yeast and bacterial cells may require a homogenizer.
- After the cells have been homogenized or lysed in TRI Reagent, samples can be stored at –70 °C for up to 1 month.

- Phase Separation: To ensure complete dissociation of nucleoprotein complexes, allow samples to stand for 5 minutes at room temperature. Add 0.1 ml of 1-bromo-3-chloropropane or 0.2 ml of chloroform (see Phase Separation, notes a and b) per ml of TRI Reagent used. Cover the sample tightly, shake vigorously for 15 seconds, and allow to stand for 2–15 minutes at room temperature. Centrifuge the resulting mixture at 12,000 × g for 15 minutes at 2–8 °C. Centrifugation separates the mixture into 3 phases: a red organic phase (containing protein), an interphase (containing DNA), and a colorless upper aqueous phase (containing RNA).

##### Notes:

- 1-Bromo-3-chloropropane is less toxic than chloroform and its use for phase separation decreases the possibility of contaminating RNA with DNA.<sup>4</sup>
- The chloroform used for phase separation should not contain isoamyl alcohol or other additives.
- For isolation of poly A<sup>+</sup> fraction from the aqueous phase see Appendix I.

#### RNA Isolation

- Transfer the aqueous phase to a fresh tube and add 0.5 ml of 2-propanol per ml of TRI Reagent used in Sample Preparation, step 1 and mix. Allow the sample to stand for 5–10 minutes at room temperature. Centrifuge at 12,000 × g for 10 minutes at 2–8 °C. The RNA precipitate will form a pellet on the side and bottom of the tube. **Note:** Store the interphase and organic phase at 2–8 °C for subsequent isolation of the DNA and proteins.
- Remove the supernatant and wash the RNA pellet by adding a minimum of 1 ml of 75% ethanol per 1 ml of TRI Reagent used in Sample Preparation, step 1. Vortex the sample and then centrifuge at 7,500 × g for 5 minutes at 2–8 °C. **Notes:**
  - If the RNA pellets float, perform the wash in 75% ethanol at 12,000 × g.
  - Samples can be stored in ethanol at 2–8 °C for at least 1 week and up to 1 year at –20 °C.

3. Briefly dry the RNA pellet for 5–10 minutes by air-drying or under a vacuum. Do not let the RNA pellet dry completely, as this will greatly decrease its solubility. Do not dry the RNA pellet by centrifugation under vacuum (Speed-Vac®). Add an appropriate volume of formamide, water, or a 0.5% SDS solution to the RNA pellet. To facilitate dissolution, mix by repeated pipetting with a micropipette at 55–60 °C for 10–15 minutes.

**Notes:**

- Final preparation of RNA is free of DNA and proteins. It should have a  $A_{260}/A_{280}$  ratio of  $\geq 1.7$ .
- Typical yields from tissues ( $\mu\text{g}$  RNA/mg tissue): liver, spleen, 6–10  $\mu\text{g}$ ; kidney, 3–4  $\mu\text{g}$ ; skeletal muscle, brain, 1–1.5  $\mu\text{g}$ ; placenta, 1–4  $\mu\text{g}$ .
- Typical yields from cultured cells ( $\mu\text{g}$  RNA/ $10^6$  cells): epithelial cells, 8–15  $\mu\text{g}$ ; fibroblasts, 5–7  $\mu\text{g}$ .
- Ethidium bromide staining of RNA in agarose gels visualizes two predominant bands of small (2 kb) and large (5 kb) ribosomal RNA, low molecular mass (0.1–0.3 kb) RNA, and discrete bands of high molecular mass (7–15 kb) RNA.

### DNA Isolation

- Carefully remove the remaining aqueous phase overlaying the interphase and discard. To precipitate the DNA from the interphase and organic phase, add 0.3 ml of 100% ethanol per 1 ml of TRI Reagent used in Sample Preparation, step 1. Mix by inversion and allow to stand for 2–3 minutes at room temperature. Centrifuge at  $2,000 \times g$  for 5 minutes at 2–8 °C.

**Note:** Removal of the remaining aqueous phase before DNA precipitation is a critical step for the quality of the isolated DNA.

- Remove the supernatant and save at 2–8 °C for protein isolation. Wash the DNA pellet twice in 0.1 M trisodium citrate, 10% ethanol solution. Use 1 ml of wash solution for every 1 ml of TRI Reagent used in Sample Preparation, step 1. During each wash, allow the DNA pellet to stand (with occasional mixing) for at least 30 minutes. Centrifuge at  $2,000 \times g$  for 5 minutes at 2–8 °C. Resuspend the DNA pellet in 75% ethanol (1.5–2 ml for each ml TRI Reagent) and allow to stand for 10–20 minutes at room temperature.

**Notes:**

- Important:** Do not to reduce the time samples remain in the washing solution. Thirty minutes is the absolute minimum time for efficient removal of phenol from the DNA.

- If pellet contains  $>200 \mu\text{g}$  of DNA or large amounts of non-DNA material, an additional wash in 0.1 M trisodium citrate, 10% ethanol solution is required.
- Samples suspended in 75% ethanol can be stored at 2–8 °C for several months.

- Dry the DNA pellet for 5–10 minutes under a vacuum and dissolve in 8 mM NaOH with repeated slow pipetting with a micropipette. Add sufficient 8 mM NaOH for a final DNA concentration of 0.2–0.3  $\mu\text{g}/\mu\text{L}$  (typically 0.3–0.6 ml to the DNA isolated from 50–70 mg of tissue or  $10^7$  cells). This mild alkaline solution assures complete dissolution of the DNA pellet. Centrifuge at  $12,000 \times g$  for 10 minutes to remove any insoluble material and transfer the supernatant to a new tube.

**Notes:**

- A viscous supernatant indicates the presence of high molecular mass DNA.
- The size of the DNA will depend on the force exerted during homogenization. Avoid using a Polytron homogenizer.
- Samples dissolved in 8 mM NaOH can be stored at 2–8 °C overnight. For long term storage, adjust the pH value to between 7 and 8 and supplement with EDTA (final concentration 1 mM).
- To determine DNA concentration, remove an aliquot, dilute with water, and measure the  $A_{260}$ . For double stranded DNA,  $1 A_{260} \text{ unit/ml} = 50 \mu\text{g/ml}$ .
- To calculate cell number, assume the amount of DNA for  $10^6$  diploid cells of human, rat, and mouse equals 7.1  $\mu\text{g}$ , 6.5  $\mu\text{g}$ , and 5.8  $\mu\text{g}$ , respectively.
- Typical yields from tissues ( $\mu\text{g}$  DNA/mg tissue): liver, kidney, 3–4  $\mu\text{g}$ ; skeletal muscle, brain, and placenta, 2–3  $\mu\text{g}$ .
- Typical yields from cultured human, rat, and mouse cells: 5–7  $\mu\text{g}$  DNA/ $10^6$  cells.

### To Amplify DNA by PCR

After dissolving in 8 mM NaOH, adjust to pH 8.4 using HEPES (add 86  $\mu\text{L}$  of 0.1 M HEPES, free acid/ml of DNA solution). Add sample (generally 0.1–1  $\mu\text{g}$ ) to PCR mix and follow PCR protocol.

### To Digest DNA with Restriction Enzymes

Adjust the pH of the DNA solution to that needed for the restriction enzyme digestion using HEPES, or dialyze samples against 1 mM EDTA, pH 7–8. Allow the restriction enzyme digestion to continue for 3–24 hours under optimal conditions. It is recommended that 3–5 units of enzyme be used per 1  $\mu$ g of DNA. Typically, 80–90% of the DNA is digested.

### Protein Isolation

1. Precipitate proteins (see note) from the phenol-ethanol supernatant (DNA Isolation, step 2) with 1.5 ml of 2-propanol per 1 ml of TRI Reagent used in Sample Preparation, step 1. Allow samples to stand for at least 10 minutes at room temperature. Centrifuge at  $12,000 \times g$  for 10 minutes at 2–8 °C. **Note:** For some samples, the protein pellet may be difficult to dissolve in 1% SDS (step 3). Use this alternate procedure to correct the problem:
  - a. Dialyze the phenol-ethanol supernatant against 3 changes of 0.1% SDS at 2–8 °C.
  - b. Centrifuge the dialysate at  $10,000 \times g$  for 10 minutes at 2–8 °C.
  - c. The clear supernatant contains protein that is suitable for use in Western blotting procedures.
2. Discard supernatant and wash pellet 3 times in 0.3 M guanidine hydrochloride/95% ethanol solution, using 2 ml per 1 ml of TRI Reagent used in Sample Preparation, step 1. During each wash, store samples in wash solution for 20 minutes at room temperature. Centrifuge at  $7,500 \times g$  for 5 minutes at 2–8 °C. After the 3 washes, add 2 ml of 100% ethanol and vortex the protein pellet. Allow to stand for 20 minutes at room temperature. Centrifuge at  $7,500 \times g$  for 5 minutes at 2–8 °C. **Note:** Protein samples suspended in 0.3 M guanidine hydrochloride/95% ethanol solution or 100% ethanol can be stored for 1 month at 2–8 °C or 1 year at –20 °C.
3. Dry protein pellet under a vacuum for 5–10 minutes. Dissolve pellet in 1% SDS aided by working the plunger of micropipette with tip in the solution. Remove any insoluble material by centrifugation at  $10,000 \times g$  for 10 minutes at 2–8 °C. Transfer supernatant to a new tube. The protein solution should be used immediately for Western blotting or stored at –20 °C.

### **Troubleshooting Guide**

1. RNA Isolation:
  - A. Low yield may be due to:
    - incomplete homogenization or lysis of samples.
    - the final RNA pellet may not have been completely dissolved.
  - B. If the  $A_{260}/A_{280}$  ratio is <1.65:
    - the amount of sample used for homogenization may have been too small.
    - samples may not have been allowed to stand at room temperature for 5 minutes after homogenization.
    - there may have been contamination of the aqueous phase with the phenol phase.
    - the final RNA pellet may not have been completely dissolved.
  - C. If there is degradation of the RNA:
    - the tissues may not have been immediately processed or frozen after removing from the animal.
    - the samples used for isolation or the isolated RNA preparations may have been stored at –20 °C instead of –70 °C as specified in the procedure.
    - cells may have been dispersed by trypsin digestion.
    - aqueous solutions or tubes used for procedure may not have been RNase-free.
    - formaldehyde used for the agarose gel electrophoresis may have had a pH value <3.5.
  - D. If there is DNA contamination:
    - the volume of reagent used for the sample homogenization may have been too small.
    - samples used for the isolation may have contained organic solvents (ethanol, DMSO), strong buffers or alkaline solution.
2. DNA Isolation:
  - A. Low yield may be due to:
    - incomplete homogenization or lysis of samples.
    - the final DNA pellet may not have been completely dissolved.
  - B. If the  $A_{260}/A_{280}$  ratio is <1.70:
    - phenol may not have been sufficiently removed from the DNA preparation. Try one more wash of the DNA pellet with the 0.1 M trisodium citrate, 10% ethanol solution.

- C. If there is degradation of the DNA:
- the tissues may not have been immediately processed or frozen after removing from the animal.
  - the samples used for isolation may have been stored at  $-20^{\circ}\text{C}$  instead of  $-70^{\circ}\text{C}$  as specified in the procedure.
  - samples may have been homogenized with a Polytron or other high speed homogenizer.
- D. If there is RNA contamination:
- there may have been too much aqueous phase remaining with the organic phase and interphase.
  - the DNA pellet may not have been washed sufficiently with 0.1 M trisodium citrate, 10% ethanol solution.
3. Protein Isolation:
- A. Low yield may be due to:
- incomplete homogenization or lysis of samples.
  - the final protein pellet may not have been completely dissolved.
- B. If there is degradation of the protein:
- the tissues may not have been immediately processed or frozen after removing from the animal.
- C. If PAGE shows band deformation:
- protein pellet may not have been washed sufficiently.

## Appendix

### I. Isolation of Poly A<sup>+</sup> RNA

After the RNA has been precipitated with 2-propanol (RNA Isolation, step 1), dissolve the pellet in poly A<sup>+</sup> binding buffer and pass through an oligo-dT cellulose (Catalog Number O3131) column to selectively remove mRNA according to the procedure of Aviv and Leder.<sup>3</sup>

### II. Isolated RNA is to be used in RT-PCR

1. Modifying the procedure by performing the additional centrifugation step in the initial Sample Preparation, step 1B, note c further minimizes the possibility of DNA contamination in the RNA extracted by TRI Reagent LS.
2. A more complete evaporation of ethanol is required when RNA samples are to be used in RT-PCR. This is especially critical for small volume samples (5–20  $\mu\text{l}$ ), which may contain a relatively high level of ethanol if not adequately dried.

## References

1. Chomczynski, P., *BioTechniques*, **15**, 532-537 (1993).
2. Chomczynski, P., and Sacchi, N., *Anal. Biochem.*, **162**, 156-159 (1987).
3. Aviv, H., and Leder, P., *Proc. Natl. Acad. Sci. USA*, **69**, 1408-1412 (1972).
4. Chomczynski, P., and Mackey, K., *Anal. Biochem.*, **225**, 163-164 (1995).

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